Annual Report 2021

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Acknowledgements

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Abbreviations & acronyms

AGNES	:	African German Network of Excellence in Science
EDCTP	:	European and Developing Countries Clinical Trials Partnership ()
FSA	:	Faculty of Agronomic Sciences (in English)
HRH	:	Humboldt Research Hub
IF	:	Impact factor
IFS	:	International Foundation for Science
INRAB	:	Institut National de la Recherche Agricole du Bénin (National Institute of Agricultural Research of Benin)
LABEF	:	Laboratoire de Biomathématiques et d'Estimations Forestières
MSc	:	Master of Sciences
Ph.D.	:	Doctor of Philosophy
RUFORUM	:	Regional Universities Forum for Capacity Building in Agriculture
UAC	:	University of Abomey-Calavi
UNA	:	Université Nationale d'Agriculture
UP	:	University of Parakou
WIF	:	Without Impact Factor

Statement of the head of the Lab

Dear colleagues and friends,

I am delighted, as usual, to introduce the 2021 annual report of the "Laboratoire de Biomathématiques et d'Estimations Forestières" (LABEF).

The global pandemic of COVID-19 has continued in 2021 and has been challenging as the year 2020. However, the commitment of our team despite the many disruptions of our activities due to the pandemic made it possible to achieve the insightful milestones highlighted in this report. There has been significant progress of team members, and we have attracted several post-docs and students to our different research units.

Thanks to the commitment of our proactive members, we have sustained our standards in terms of the amount and the quality of scientific articles. Although we still have room for improvement, I would like to take this opportunity to congratulate all the members for their efforts and contributions to increasing the visibility of the laboratory through the quality of our research and the relevance of our research to society.

Enjoy reading this report, and I look forward to sharing with you the future progress of LABEF.

Prof. Romain Glèlè Kakaï

Head of LABEF

CHAPTER 1.

LABEF: Overview and Team

1.1. Mission, vision, and objectives of LABEF

Created on 27th May 2014 by Romain Glèlè Kakaï, Professor in biometry and forest estimations, the "Laboratoire de Biomathématiques et d'Estimations Forestières", is part of the "Ecole d'Aménagement et Gestion de l'Environnement", Faculty of Agronomic Sciences, University of Abomey-Calavi.

The Laboratory aims to:

- raise awareness of the importance of Mathematics, particularly Statistics in Biological Sciences;
- analyze the applicability of mathematical tools in life sciences with a particular focus on understanding the interactions between ecological processes, anthropogenic factors, and terrestrial ecosystems' structure to deliver clear management actions and policies.

The mission of LABEF is to enhance understanding of biological systems through the effective use of biomathematics.

Its vision is to be, by 2030, a leading institution in developing mathematical tools for biologists and supporting decision-makers in forestry for a better society.

1.2. Organization of LABEF

LABEF is organized into four departments, including the (i) fundraising department, (ii) social life department, (iii) administrative department, and (iv) research department. The research department now includes three units, namely: Unit of Biomathematics (UBM), Unit of Artificial Intelligence and Machine Learning (UAIML), and Unit of Forest Estimations (UFE).

- **The Unit of Biomathematics (UBM)** deals with biology and mathematics and is interested in applications of mathematics in biology. This unit is interested in the use of mathematical theories in biology and especially in publishing scientific notes describing the application of different mathematical tools in life sciences.
- **The Unit of Forest Estimations (UFE)** falls into the overall perspective of assessing wood resources, biomass, and carbon stock available in forest ecosystems. The Unit is interested in developing accurate and robust methods and models for estimating forest resources. It is equally interested in understanding ecological processes and patterns and developing clear and applicable management policies for forest managers and decision-makers. The unit also investigates forest governance approaches, effectiveness, replicability,

socio-economic and ecological outcomes, decision-making process, and benefit-sharing.

- **The Unit of Artificial Intelligence and Machine Learning (UAIML)** aims to operationalize and develop machine learning (ML) and artificial intelligence (AI) methods to assist innovation in the field of biology, particularly Forestry and Agriculture.

1.3. Research topic covered at LABEF

The ecosystem of research topics covered at LABEF is diverse and illustrated in figure 1.

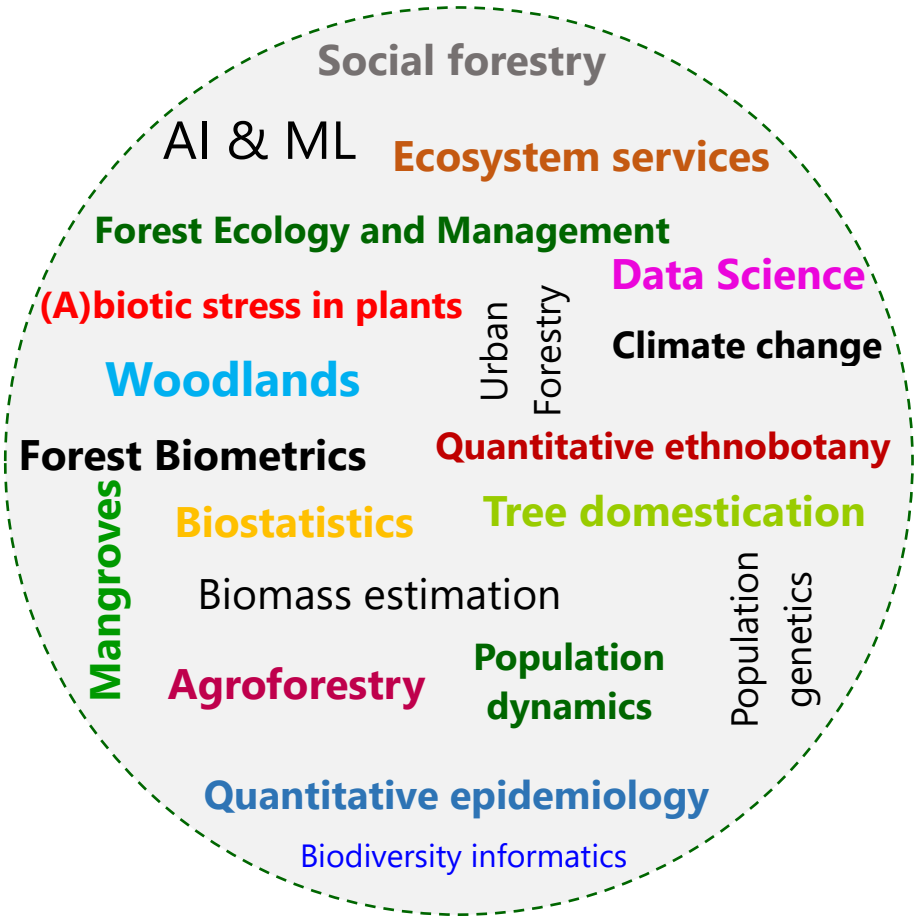

Figure 1. View of research topics covered at LABEF

1.4. The core management team of LABEF in 2021

Prof Romain Glèlè Kakaï is the head of LABEF. He is a Full Professor in Biometry and Forestry, researcher, and lecturer at the Faculty of Agronomic Sciences. Prof Glèlè Kakaï is the chairman of the scientific council of agronomic sciences, chairman of the Scientific Council of the National Institute of Agricultural Research of Benin (INRAB), and chairman of the African German Network of Excellence in Science (AGNES). He is also coordinating the Doctoral program in Biometry at the University of Abomey-Calavi. His research areas include Linear and nonlinear mixed models - Generalized linear models - Multiblock data analysis - Forest estimations - Forest management.

Dr Jonas Doumate is the deputy head of LABEF and head of the Biomathematics research unit. He is Assistant Professor of Mathematics. His research areas include Applied mathematics – Analysis - Mathematical Statistics - Series Analysis – and Financial Mathematics.

Dr Emile Agbangba is the head of the Artificial Intelligence and Machine Learning research unit. His research areas include Machine Learning – Statistical Probability - Climate Science - Linear and nonlinear mixed models.

Dr Kolawolé Valère Salako is the scientific coordinator and head of the research unit in Forest estimations. He is a lecturer and researcher in Forestry and Biometry. His research areas include population and community ecology – Forest Biometrics – agroforestry systems analysis – multivariate methods in community ecology.

Dr Marcel Donou is the head of the social life department. He is also the Teaching manager of the Master Program: Major Biostatistics. His research areas include population Ethnobiology - Conservation Biology – Forest Biometrics.

Carl AKOTO is leading the administrative department. He is in charge of the administration and all related tasks. He assists the coordinator of the master program in statistics major Biostatistics for students' day-to-day management. He ensures that students have their timetable, receive their lectures, submit their homework, and sit their exams on time.

CHAPTER 2

RESEARCH: *Milestones & Highlights*

2.1. Scientific publications in 2021

2.1.1. Publications Milestones

In 2021, LABEF produced a total of 51 scientific documents. Among these documents (figure 2), 96.08% were scientific publications in peer-review journals (49 published papers), and 3.92% were books and book chapters (2 documents).

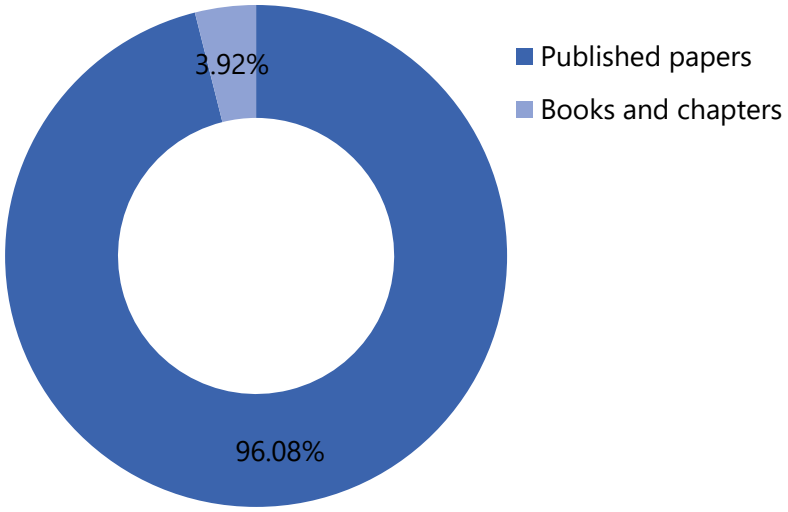

Figure 2. Scientific documents produced by LABEF in 2021

2.1.2. Diversity of Journals and scientific disciplines covered by publications of LABEF in 2021

In 2021, the scientific articles were published in 40 journals as summarized in table 1. Several research domains were covered. Among the seventeen research domains covered, plant ecology (8 published papers), biostatistics (5 published papers), crop production (5 published papers), natural resources management (5 published papers), agroforestry (3 published papers), climate change (3 published papers), and ethnobotany (3 published papers) were the most investigated (figure 3).

Table 1. *Diversity of journals for published, in press, and under review papers*

Journals	Type of journals	Impact factor (IF)	Number of papers
Advances in Traditional Medicine	IF	1.34	1
African Journal of Ecology	IF	1.426	2
Agroforestry systems	IF	2.549	1
Agronomy	IF	3.417	1
Annales des sciences agronomiques	WIF	-	1
Biology	IF	3.796	1
BioTechnologia. Journal of Biotechnology Computational Biology and Bionanotechnology	WIF	-	1
Biotechnologie, Agronomie, Société et Environnement	IF	1.087	1
Bois et Forêts des Tropiques	IF	0.692	1
Bulletin de la Recherche Agronomique du Bénin (BRAB)	WIF	-	3
Chemometrics and Intelligent Laboratory Systems	IF	3.491	1
Ecology and Evolution	IF	2.91	1
Ecosphere	IF	3.171	1
Environment, Development and Sustainability	IF	3.219	3
Environmental Science and Engineering	IF	0.280	1
Forest Ecology and Management	IF	3.558	1
Forests	IF	2.116	1
Frontiers in Sustainable Food Systems	IF	3.95	1
Genetic Resources and Crop Evolution	IF	1.524	3
Global Ecology and Biogeography	IF	7.148	1
Global Ecology and Conservation	IF	3.380	1
Global Food Security	IF	7.772	1
Heliyon	WIF	-	2
Infectious Disease Modelling	IF	1.332	1
International Journal of Tropical Insect Science	IF	0.774	1
Journal of Animal & Plant Sciences	WIF	-	1
Journal of Arid Environments	IF	2.22	1
Journal of Land Use Science	IF	2.885	1
Land Use Policy	IF	5.398	1
Mathematics	IF	1.747	1
Modeling Earth Systems and Environment	IF	2.83	1
National Academy of Agricultural Sciences	IF	0.99	1
Natural Resources Forum	IF	1.821	1
Plant Ecology and Evolution	IF	1.366	1
PLoS ONE	IF	3.24	1
Science de la vie, de la terre et agronomie	WIF	-	1
Science of the Total Environment	IF	7.963	2
Trees, Forests and People	WIF	-	1
Tropical Ecology	IF	0.850	1
Wetlands Ecology and Management	IF	1.379	1

IF = Impact factored journals, WIF = Without impact factor journals

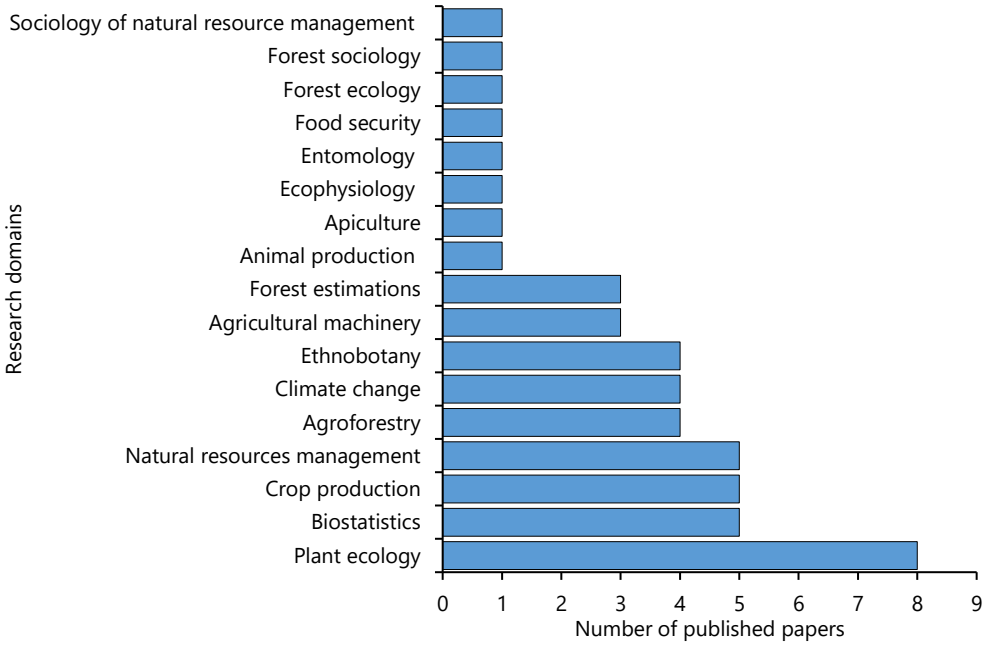

Figure 3. *Diversity of research domains for published papers by LABEF in 2021*

2.1.3. Performance and highlights in publication

LABEF produced slightly more scientific articles in 2021 than in 2020, and the trend has been increasing since 2014 (figure 4a). Among the 51 documents of 2021, 49 were scientific publications in peer-review journals, with 39 publications in impact factor journals in 2021, higher than the 24 publications in impact factor journals in 2020 (figure 4b). So, 79.59% of the scientific articles are published in journals with an impact factor (figure 4c). Therefore, the standard of quality in publishing is significantly higher in 2021 than in 2020.

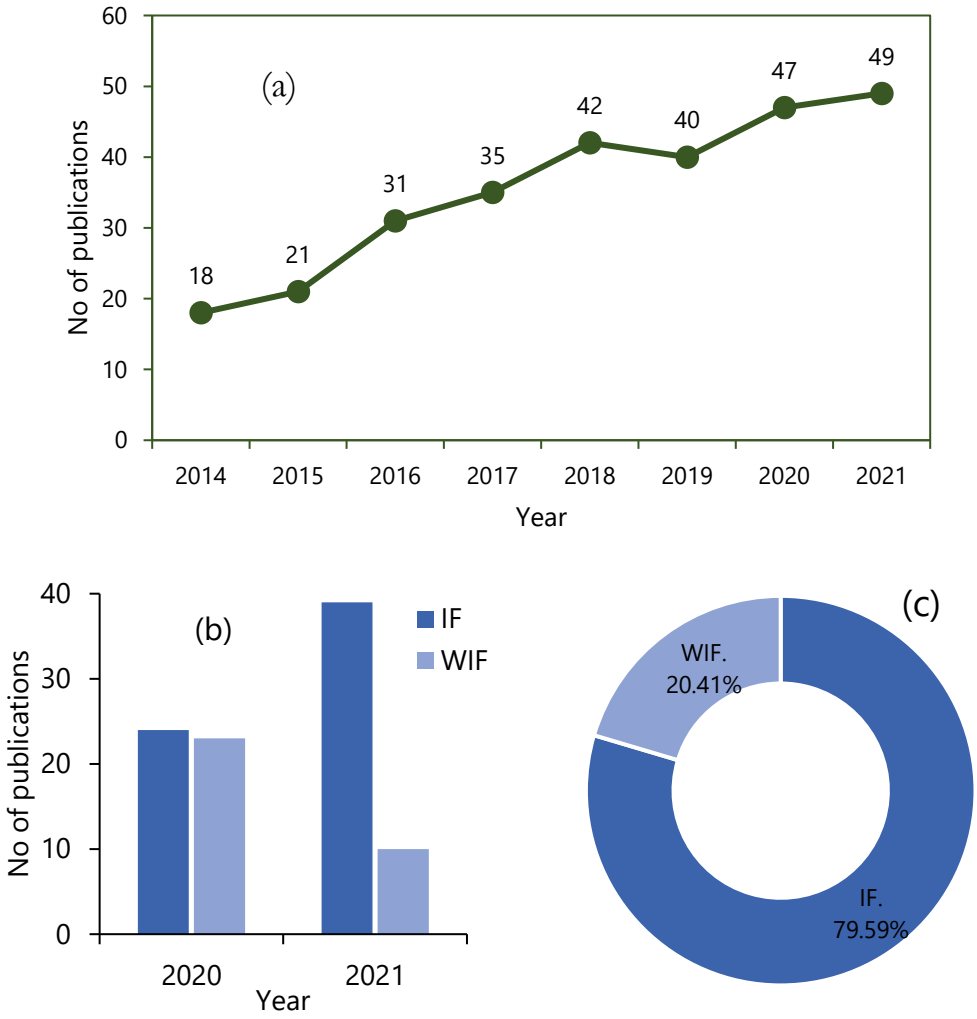

Figure 4. *Trends in annual publications from 2014 (a), types of published documents compared to the year 2020 (b) and quality of publications (c). IF = Impact factored journals, WIF = Without impact factor journals*

The cumulative impact factor was 110.496 in 2021, higher than that in 2020 (59.051), illustrating that, members of LABEF have published their articles in journals with a higher impact factor than 2020 (figure 5).

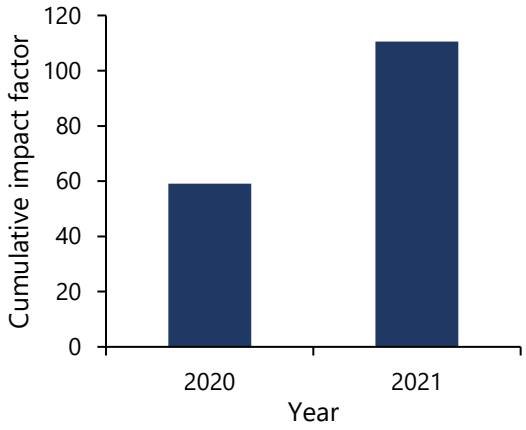

Figure 5. *Cumulative impact factor in 2020 and 2021*

Among the papers published in peer-review journals with an impact factor in 2021, 12.12% were in journals with an impact factor above 5, 45.45% in journals with an impact factor between 2 and 5, and 27.27% in journals with an impact factor between 1 and 2 (figure 6).

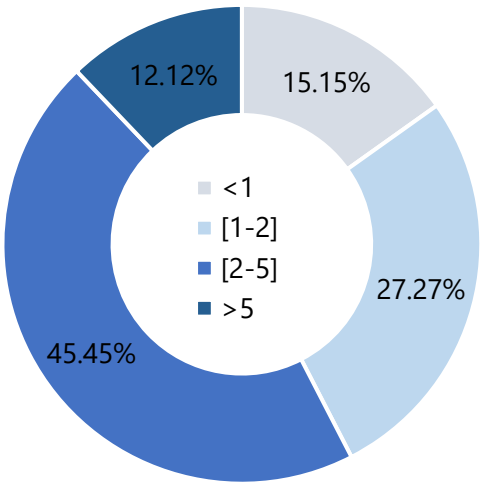

Figure 6. *Range of impact factor of published papers*

2.1.4. Authorship and leadership position in publications in 2020 and 2021

For the 51 scientific papers published in 2021, members of LABEF have occupied variable positions. Members of the lab were exclusively the first author in four published papers (7.84%). In 35.29% of the published papers, members of LABEF were among the first three authors (figure 7). The leadership (last) position was occupied by members of the lab in 5.88% of the published papers, while in 35.29% of the papers, the last as well as the first positions were ruled by LABEF's members.

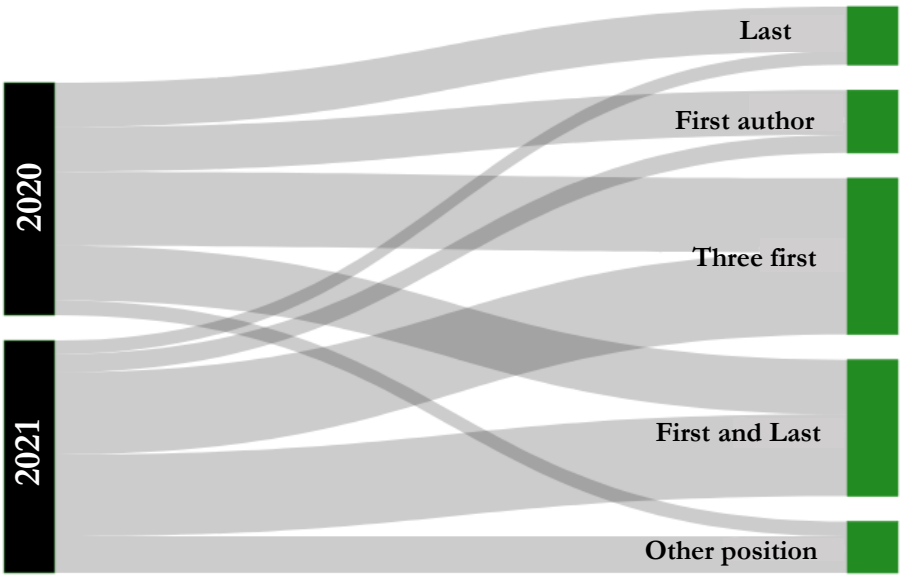

Figure 7. *(Co-) Authorship position of LABEF members in publications in 2021*

2.2. Research initiatives related to COVID-19

To contribute to the scientific debate around the health crisis, LABEF undertook, since April 2020, research on the dynamics of the first wave of COVID-19 in West Africa. Through these works, the impacts of non-pharmaceutical interventions and efficient management scenarios of the pandemic were investigated. The team devoted to this work within the laboratory consists largely of masters and Ph.D. students and postdoctoral fellows who had the opportunity to put into practice and in real-time the knowledge and skills gained during their training in Biostatistics. From these research activities, six scientific publications have been prepared, among which four have been published in 2021 and two others in revision. The lab has also organized a scientific seminar to share the findings with the scientific community of Benin at the University of Abomey-Calavi on September 8th, 2021 (photo 1).

- Gnanvi J., Salako K.V., Kotanmi B., Glèlè Kakaï, R. (2021). On the reliability of predictions on Covid-19 dynamics: A systematic and critical review of modelling techniques. Infectious Disease Modelling 6 (2021) 258-272. https://doi.org/10.1016/j.idm.2020.12.008
- Tovissodé C.F., Doumatè J.T., Glèlè Kakaï R. (2021). A Hybrid Modeling Technique of Epidemic Outbreaks Application to COVID-19 Dynamics in West Africa. Biology, 10, 365. https://doi.org/10.3390/biology1005036
- Gnansounou S.C., Abdul-Kareem R., Gbedomon R.C., Salako K.V., Mensah G.A., Glèlè Kakaï R. (2021). Impact of Covid-19 on Coastal Fishing and Stakeholders' Response Strategies in Benin, West Africa. Journal of Coastal Research, 00(0), 000–000, https://10.2112/JCOASTRES-D-21-00048.1

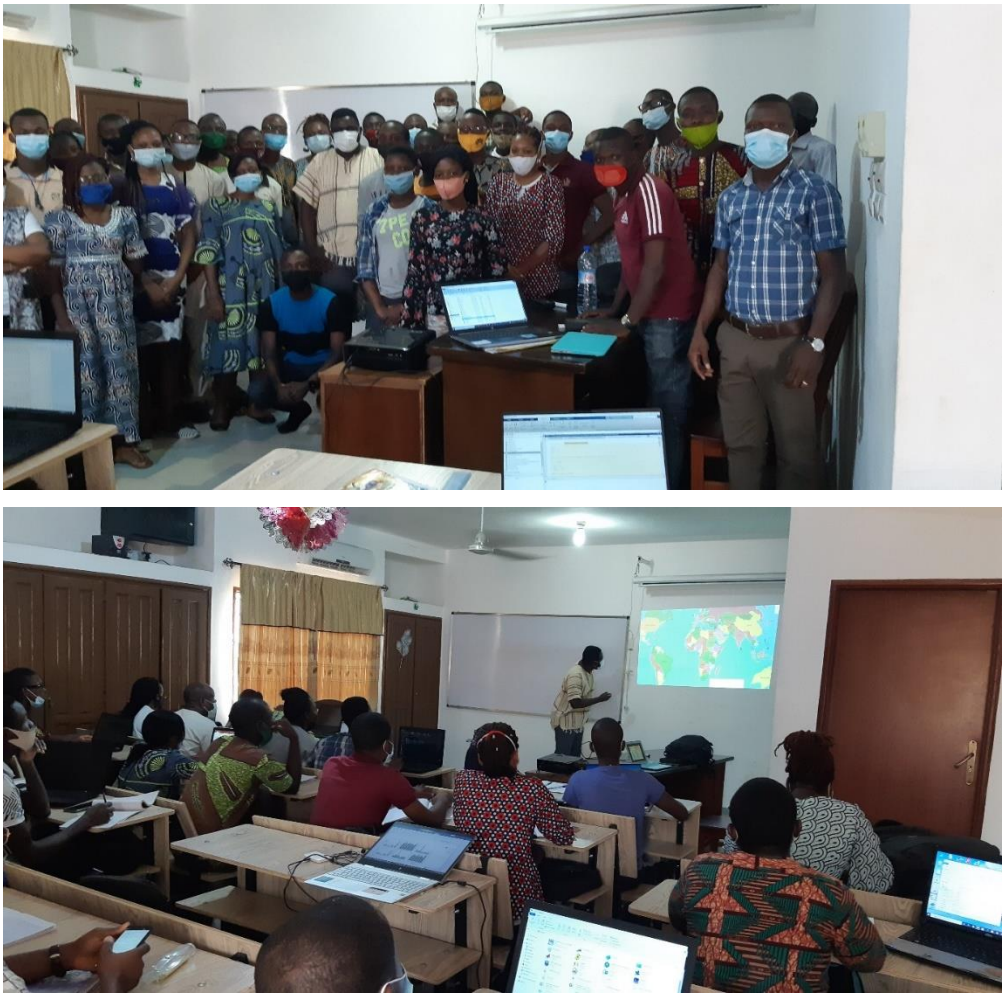

Photo 1. *Guest lecturer (Professor NGONGHALA Calistus) and participants at the seminar on Infectious Disease Modeling (credit: Dr Salako Valère)*

2.3. Research projects in 2021

The research projects implemented by LABEF in 2021 included, as usual small (less than USD 25000), medium (USD 25 000-200 000), and large (more than USD 200 000) grants. Six individual small grants were implemented by members of LABEF in 2021 (see table 2).

Table 2. *Individual small research grants in LABEF in 2021*

N°	Funder	Recipient	Topic/subject
1	International Foundation for Science	MENSAH Sylvanus	Assessing the effects of abiotic and biotic factors on the relationship between tree diversity and aboveground tree carbon in West African forests and tree savannas
2	British Ecological Society	MENSAH Sylvanus	Quantifying tree species diversity effects on aboveground tree carbon stock in mixed forest stands in Benin
3	International Foundation for Science	Lokonon E. Bruno	Rural communities-based approach for the sustainable conservation of Caesalpinia bonduc (L.) Roxb in Central and Northern Benin
4	International Tropical Timber Organization	Lokonon E. Bruno	Technical Document Preparation on the Impact of COVID-19 on Sustainable Forest Management in West Africa: cases of Benin, Ivory Coast and Ghana.
5	Artificial Intelligence for Development — AI4D Africa	TAHI Souand	Optimisation of machine learning techniques performances in the prediction of yield of maize cultures under several controlled weather and fertilization patterns
6	Artificial Intelligence for Development — AI4D Africa	HOUETOHOSSOU Ariane	Architectural and parametric optimization of pre-trained Deep Learning algorithms for stress detection on tomato plants under climate and infection based stimulated environment.

Four medium and one large research projects were hosted by LABEF in 2021 (Table 3). In the frame of these projects, LABEF partnered with several institutions from diverse countries in Africa (Mali; Burkina Faso; Niger), Europe (Belgium, Denmark), and America (Costa Rica). For more details on medium and large projects, please visit our website: www.labef-uac.org

Table 3. *Medium and large research projects in LABEF in 2021*

N°	Project title	Project type	Partner countries	Funding institution	Period
1	Scaling up African baobab food products valuation through enhancement of their safety and value chains for food and nutritional security in Benin (West Africa)	Medium	Benin	Mastercard Foundation & The Regional Universities Forum for Capacity Building in Agriculture (RUFORUM)	2018-2022
2	Mentoring young men and women agricultural graduates in the search for decent jobs in the labor market	Medium	Benin	International Development Research Centre (IDRC)	2019-2021
3	Restauration, conservation et gestion durable des zones humides côtières du Costa Rica face au changement climatique	Medium	Costa Rica ; Benin	French Facility for Global Environment (FFEM)	2018-2022
4	Modeling nonlinear trend in multilevel data using flexible distributions: a guideline for selecting the best of parametric and semi-nonparametric approaches	Medium	Benin	TWAS	2010-2021
5	"In-Country/In-Region Scholarship Programme" for Master in Statistics (Major Biostatistics) & Doctorate in Biometrics	Large	Africa	Deutscher Akademischer Austauschdienst German Academic Exchange Service (DAAD)	2019-2022
6	Training epidemiologists and biostatisticians for enhanced response to disease outbreak and epidemic in west Africa – TEBWA	Large	Benin, United Kingdom	European and Developing Countries Clinical Trials Partnership (EDCTP2 / European Union)	2021-2023
7	Humboldt Research Hub Socio-Ecological Modeling of COVID-19 dynamics in Africa (HRH-SEMCA)	Large	Benin, Germany	Humboldt Foundation	2021-2024
8	DELTAS Africa II. Sub-Saharan Africa Consortium for Advanced Biostatistics training. Role: coordinator in Benin (SSACAB)	Large	South Africa, Tanzanie, Malawi, DRC, Benin, Ghana, etc.	African Union	2021-2025

2.4. Bachelor, Master, and Ph.D. degree dissertations in 2021

Two (02) students (one male and one female) completed their BSc training and defended their dissertation in natural resources management in 2021. Thirteen (13) MSc students (6 females and 7 males) completed their MSc degree at LABEF (figure

8a). Among them, 11 were completed in biostatistics and 2 in natural resources management (figure 8b).

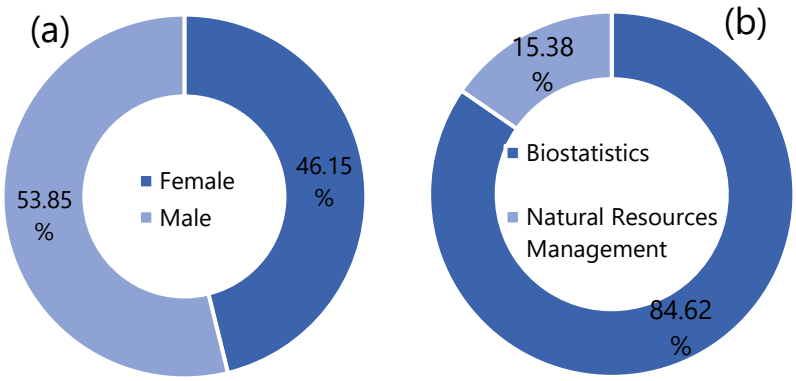

Figure 8. *Gender balance (a) and fields of research (b) for Master theses*

As far as Ph.D. students were concerned in 2021, five students (3 males and 2 females) defended their theses (three in Biometry, one in Natural Resources Management, and one in Climate change and Biodiversity respectively). Eighteen Ph.D. initiatives are ongoing (4 females and 14 males). These Ph.D. initiatives covered several research domains, with, biostatistics being the most investigated discipline (10 initiatives, see figure 9a). Moreover, 44.44% of the Ph.D. students are in their second year, while 11.11% are in their third year in 2021 (figure 9b).

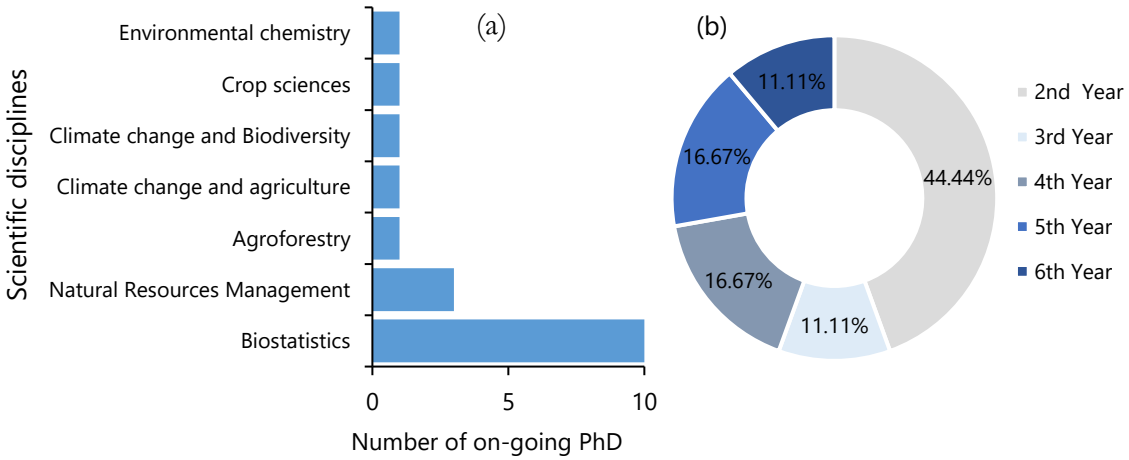

Figure 9. *Fields of research (a) and stages of ongoing Ph.D. theses in 2021*

CHAPTER 3

RESEARCH: *Connection, share, and networking*

3.1. Collaboration for publication in 2021

Collaboration for publications was done with researchers from several countries. In 2021, LABEF members collaborated with researchers from 32 countries, national collaborations being the most dominant (43%, figure 10a). The most represented continent for these collaborations was Africa more than 67%, followed by Europe more than 22% (figure 10b). LABEF members represented about 16% of researchers (figure 10c).

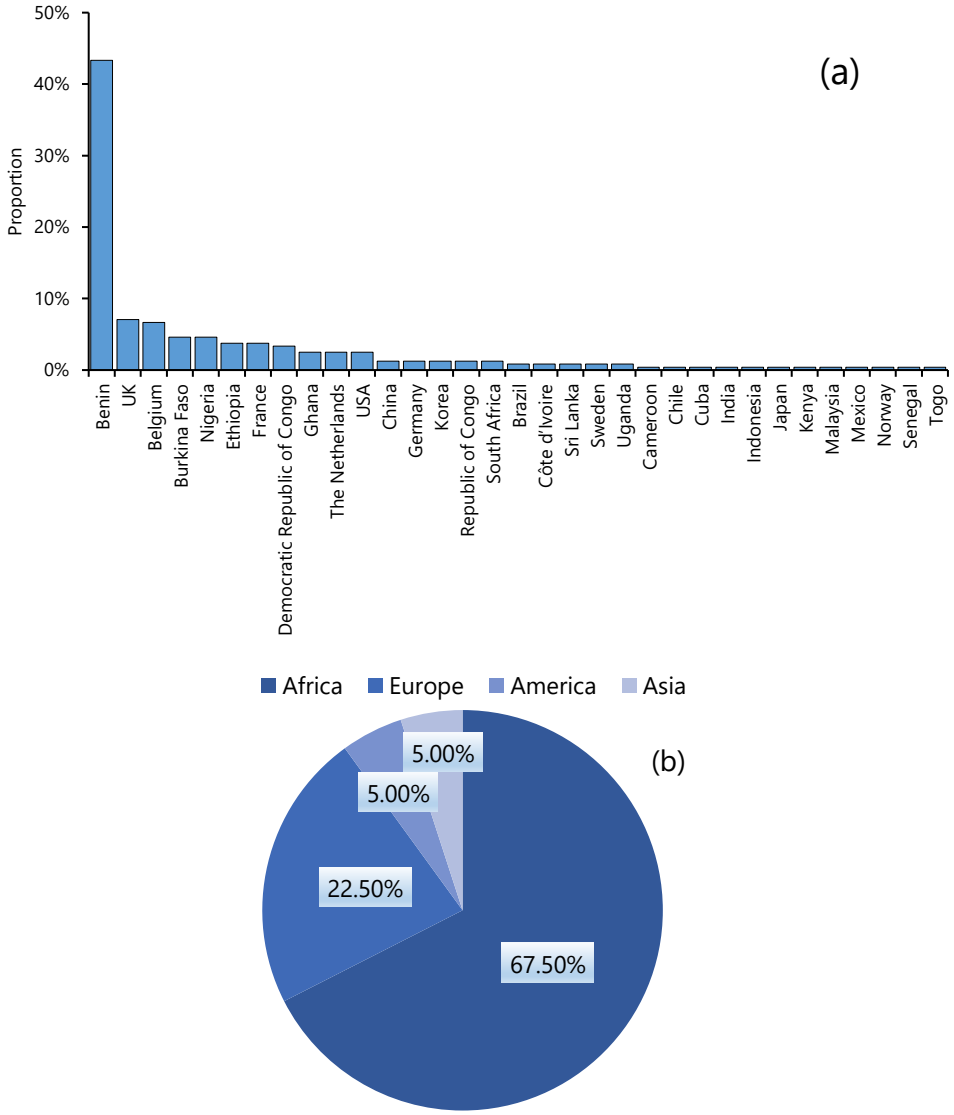

Figure 10. Countries (a) and world regions (b) of co-authors of publications of LABEF in 2021

3.2. Visitors to LABEF in 2021

In 2021, The COVID-19 global pandemic significantly affected the flow of visitors to LABEF. Several visits were announced but the international travel restriction, only one post-Doc researcher was able to visit LABEF in 2021, but LABEF has been working with several post-doc remotely.

CHAPTER 4

CONTRIBUTION: *Capacity building*

4.1. Graduate program in Biostatistics and Doctoral program in Biometry

4.1.1. Graduate program in Biostatistics (MBIOST)

4.1.1.1. Presentation of the MBIOST

Since its creation in May 2014, LABEF has been running an international graduate program in Biostatistics. This master's program offers extensive and unique training in recent statistical methods and tools toward their applications in Life sciences. At the end of the training, graduated students can easily go into professional life as Biostatisticians or engage in research in Biostatistics by integrating into a doctoral school. This training is open to Bachelor's Degree holders in Life Sciences domains (agronomy, health, biology, environment, etc.), or in Mathematics/Statistics or Master, Degree holders wishing to acquire knowledge and know-how in the field of data collection and analysis. The Master in Biostatistics has fully trained and released five batches of professional biostatisticians and data analysts. The 8th batch of students started in September 20212021 and enrolled 29 students from 06 countries (Benin, Burundi, Democratic Republic of Congo, Nigeria, South Sudan, and Uganda). To date, 151 students were trained or are completing their degree in the program. The program is supported by an Intra-ACP Academic Mobility Program (AGREEMENT NUMBER 2013-4177/001-001), RUFORUM, the German Federal Ministry of Education and Research through DAAD In-Country/In Region Program, and the African Excellence Center for Mathematics Sciences and Application (ACE-MSA, through World Bank Group fund).

4.1.1.2. Aims of the MBIOST

The MBIOST program aims to provide Food Enterprises, Projects, Health Sector (Units of Clinical research), Department of Medical Information, etc.), Public and Private Research Institutions, Non-Governmental Organizations (NGO), International Organization (FAO, UNDP, World Bank, etc.), Education and International Research Institutions, talented Biostatisticians and data analysts. The abilities this training gives in data collection, data management, statistical analysis, and valorization allow graduates to practice the job of Biostatisticians in charge of Statistical Studies in various sectors. Our alumni work as data scientists and Statisticians in multiple institutions (e.g., AfricaRice, MTN, Global Fund TB, Benin National Institute of Agricultural Research, University of Malawi, University of Abomey-Calavi) and PhD-students or post-docs in Africa, Europe, Asia, and America.

4.1.1.3. How to apply?

Visit the website www.labef-uac.org and fill in the online application form (http://labef-uac.org/application). Candidates from Benin could submit their applications to the secretary of the program, located at the Laboratoire de Biomathématiques et d'Estimations Forestières. Please visit the webpage of the Master for detailed information (http://labef-uac.org/en/master/).

4.1.2. Doctoral program in Biometry

In addition, since 2017-2018, the doctoral school of agronomic sciences and water resources has been offering a Ph.D. program in Biometry under the coordination of Prof Romain Glèlè Kakaï (the head of LABEF and coordinator of the master's program in Biostatistics). Seven new members of LABEF who graduated from the Master's program in Biostatistics are currently enrolled in the PhD program. Thus, to date, 13 members of LABEF are enrolled in the Ph.D. program, and some are close to their thesis defense. In 2021, two members of the lab graduated with their Ph.D. in the program, namely Dr Hounmenou Castro, Dr Tovissodé Chénangnon Frédéric and Dr Tchandao Mangamana Essomanda).

APPENDIX 1.

Scientific activities in 2021

A1.1. Defended theses in 2021

Name	Sex	Research topic	Research field
Assogbadjo Bidossèssi Eliane Juliette	F	Biodiversity and Indigenous Knowledge in the areas surrounding the Lama Forest in Benin	Natural Resources Management
Hounmenou Castro	M	Nonlinear regression analysis multilayer perceptron neural networks for single and multidimensional outputs	Biostatistics
Sinsin Corine Bitossessi Laurenda	F	Resilience and Vulnerability of mangroves in Benin, West Africa: implications for sustainable management	Climate change and Biodiversity
Tovissodé Chénangnon Frédéric	M	Performance of Generalized Linear and Nonlinear Mixed Models under Flexible Parametric and Semi-Nonparametric Distributions applications to plant-plant interactions in *Afzelia africana* Sm.	Biostatistics
Tchandao Mangamana Essomanda	M	Unsupervised and supervised strategies of multiblock data analysis	Biostatistics

A1.2. On-going theses in 2021

N°	Name	Sex	Level	Topic	Field of research
1	Hemaho Beaugard Taboe	M	2nd year	Mathematical meta-population models of emerging and re-emerging communicable diseases' dynamic patterns in developing countries: Application to COVID-19 pandemic and Lassa Fever virus outbreak in West Africa.	Biostatistics
2	Kakpo Dolou Angeline Reine	F	3rd year	Uses, fertilizing power, populations dynamic and conservation of some agroforestry species high soil fertilizing potential in Benin.	Agroforestry
3	Hounsou-Dindin Guillaume	M	3rd year	Biodiversity and ecological status of wild oil plants implication for conservation and domestication in Benin	Natural Resources Management
4	Tahi Souand Peace Gloria	F	2nd year	Artificial Intelligence-based problem-solving in agricultural yield prediction: Optimization of Ensemble Learning techniques performances and ability of base regressors in the prediction of yield of maize cultures under several controlled weather and fertilization patterns	Biostatistics
5	Zanvo Mahoutin Gildas Serge	M	4th year	Population structure, dynamics, and ecosystem services of mangroves in southern Benin, West-Africa: implications for sustainable management	Natural Resources Management
6	Wabi Moudjahid Akorédé	M	6th year	Variabilités climatiques et riziculture au Bénin : cas des communes de Malanville, Glazoué et Tanguiéta	Crop sciences
7	Eclou Innocent Sènandé Benjamin	M	6th year	Assessing the potential of organic cotton production to improve the livelihoods of millions of poor households in Sub-Saharan Africa (SSA)	Environmental chemistry

N°	Name	Sex	Level	Topic	Field of research
9	Mushagalusa Ciza Arsène	M	2nd year	Practical use of Random Forest regression for count response data and diseases' vectors abundance prediction: application to ticks (*Rhipicephalus appendiculatus*) abundance in grazed permanent pastures	Biostatistics
10	Houetohossou Ariane	F	2nd year	Architectural and parametric optimization of pre-trained Convolutional Neural Network (CNN) application on stress detection on tomato plants under climate and infection based simulated environments	Biostatistics
11	Ehnon Gongnet Emmanuel	M	2nd year	Empirical assessment of Bayesian Maximum Entropy (BME) robustness in spatial estimation application on soil data	Biostatistics
12	Ahlonsou Biowa Ceptime Galilée	M	4th year	Empirical performance of Distance functions for farm efficiency analysis application on organic cotton farming systems in Benin	Biostatistics
13	Bourobou Judie Armel	M	2nd year	Inhomogeneous Poisson Process and its extensions for species distribution analysis: Accounting for sampling bias, imperfect detection, non-linear effect and spatial dependence.	Biostatistics
14	Mugumaarhahama Yannick	M	2nd year	Spatial point process model for analysis of presence-only data: accounting for species characteristics and uncertainties in data	Biostatistics
15	Dah-Dovonon Virgile-Marx	M	2nd year	Evaluation des stratégies innovantes d'adaptation et apport de l'information climatique dans la Gestion des risques climatiques dans les exploitations agricoles au Bénin	Climate change and agriculture
16	Donhouede Janine	F	4th year	Morphological variation, genetic diversity and proximate composition in *Annona senegalensis* in Western and Southern Africa	Natural Resources Management
17	Amagnide Aubin	M	5th year	Empirical studies of plotless sampling techniques in vegetation studies	Biostatistics

A1.3. Completed Master in 2021

N°	Name	Sex	Topic	Supervisor(s)	Field of research
1	ADEOTI O. Mathilde	F	Modelling nonlinear trend in correlated data using flexible distributions: a comparative study of parametric and semi-nonparametric approaches under the Bayesian framework	Prof Romain GLELE KAKAÏ	Biostatistics (Nonlinear Models)
2	AFFOSSOGBE Sedjro Tranquillin	M	Is Bayesian Maximum Entropy (BME) Robust for Estimation in geostatistics? A critical review	Prof Romain GLELE KAKAÏ Dr Romaric VIHOTOGBE	Biostatistics (Bayesian Statistics)
3	DOSSOUHOUI Symphorien	M	Empirical performance of parameters estimation methods in linear mixed-effects survival analysis and application in agricultural trials	Prof Romain GLELE KAKAÏ Dr Charlemagne GBEMAVO	Biostatistics (Linear Mixed Effect Models)
4	GBAGUIDI ALIA Marcel	M	COVID-19 and Scientific contributions: a review of epidemiological and social sciences research interests	Prof Romain GLELE KAKAÏ	Biostatistics (Epidemiology)
5	GUEDEZOUME Paulette	F	Critical review of GLMs outputs applied to agricultural sciences: a guideline for effective use	Prof Romain GLELE KAKAÏ	Biostatistics (Generalized Linear Models)
6	OBAONRIN Oumar Abiodoun	M	Determinants of exclusive breastfeeding using the 2017/2018 Benin demographic health survey	Prof Romain GLELE KAKAÏ	Biostatistics (Epidemiology)
7	SABI GANI Habib	F	Methods for exact perturbation analysis: simulations *boswellia papyrifera* data	Prof Romain GLELE KAKAÏ Dr Orou GAOUE	Biostatistics (Dynamics Population Modeling)
8	TANDJIEKPON Maxime	F	Assessment of the performance of distances functions methods application on organic cotton production units in Benin	Dr Epiphane SODJINOU	Biostatistics (Econometrics)
9	TEKENG ZEBAZE Gael Yanick	M	Cox model frailty penalized estimation: A simulation study	Prof Romain GLELE KAKAÏ	Biostatistics (Cox Model)
10	YEHOUENOU Narcisse	M	Performance of nonlinear mixed models under scale mixture of skew normal distributions	Prof Romain GLELE KAKAÏ	Biostatistics (Nonlinear mixed effects models)
11	YLONFOUN Armelle	F	On the performance of information criteria used for mode selection in GLMs	Prof Romain GLELE KAKAÏ	Biostatistics (Generalized Linear Models)
12	GANDJI Mirabelle	F	Diversité des usages et transmission des savoirs locaux de *Cochlospermum tinctorium* A. Rich et *Cochlospermum planchonii* Hook. F. : deux espèces négligées et sous-utilisées au Bénin	Prof. Romain Glèlè Kakaï Dr Charlemagne GBEMAVO	Ethnobotany and domestication
13	GNANSOUNOU Constant Setondé	M	Diversity of Mangrove Ecosystem Services and Drivers of Change in the Mono Transboundary Biosphere Reserve, West-Africa	Prof Denis AHETO Prof. Romain GLELE KAKAÏ	Natural Resources Management (Coastal Zone Management)

A1.4. Scientific papers published in peer-review journals IF in 2021

N°	Discipline	Authors' Names	Title of the article	Journals	IF
1	Agroforestry	Avakoudjo H.G.G., Idohou R., Salako K.V., Hounkpèvi A., Kone M.W., Assogbadjo A.E.	Diversity in tree and fruit traits of *Strychnos spinosa* Lam. along a climatic gradient in Benin: a step towards domestication	Genetic Resources and Crop Evolution	1.524
2	Agroforestry	Raveendra S.A.S.T., Nissanka S.P., Somasundaram D., Atapattu A.J., Mensah S.	Coconut-gliricidia mixed cropping systems improve soil nutrients in dry and wet regions of Sri Lanka	Agroforestry systems	2.549
3	Agroforestry	Lawin I.F., Fandohan A.B., Salako K.V., Assogbadjo A.E., Ouinsavi C.A.I.N.	Morphological variability of fruits of *Cola millenii* K. Schum. from seven phytogeographical districts in Benin: opportunity for domestication	Genetic Resources and Crop Evolution	1.524
4	Apiculture	Dossou S.A.R., Adanguidi J., Aoudji A.K.N., Gbedomon R.C.	Promotion of beekeeping: Insights from an empirical analysis of three honey value chains in Benin	Natural Resources Forum	1.821
5	Biostatistics	Mangamana E.T., Glèlè Kakaï R., Qannari E.M.	A general strategy for setting up supervised methods of multiblock data analysis	Chemometrics and Intelligent Laboratory Systems	3.491
6	Biostatistics	Tovissodé C.F., Diop A., Glèlè Kakaï R.	Inference in skew generalized t-link models for clustered binary outcome via a parameter expanded EM algorithm	PLoS ONE	3.24
7	Biostatistics	Tovissodé C.F., Doumatè J.T., Glèlè Kakaï R.	A Hybrid Modeling Technique of Epidemic Outbreaks Application to COVID-19 Dynamics in West Africa	Biology	3.796
8	Biostatistics	Gnanvi J.E., Salako K.V., Kotanmi G.B., Glèlè Kakaï R.	On the reliability of predictions on Covid-19 dynamics: A systematic and critical review of modelling techniques	Infectious Disease Modelling	1.332
9	Biostatistics	Tovissodé C.F., Honfo S.H., Doumatè J.T., Glèlè Kakaï R.	On the Discretization of Continuous Probability Distributions Using a Probabilistic Rounding Mechanism	Mathematics	1.747
10	Climate change	Sinsin C.B.L., Salako K.V., Fandohan A.B., Kouassi K.E., Sinsin B.A., Glèlè Kakaï R.	Potential climate change induced modifications in mangrove ecosystems: a case study in Benin, West Africa	Environment, Development and Sustainability	3.219
11	Climate change	Vihotogbé R., Idohou R., Vianou A., Spies P., Salako K.V., Assogbadjo A., Glèlè Kakaï R.	Abundance and effects of climate change on geographical distribution of *Mondia whitei* (Hook.f.) Skeels (Apocynaceae) in the Dahomey Gap (West Africa)	African Journal of Ecology	1.426

N°	Discipline	Authors' Names	Title of the article	Journals	IF
12	Climate change	Assogba D., Idohou R., Chirwa P., Assogbadjo A.E.	On opportunities and challenges to conserve the African baobab under present and future climates in Benin (West Africa)	Journal of Arid Environments	2.22
13	Climate change	Favi G.A., Dassou G.H., Agoundé G., Ouachinou J.M.S., Djidohokpin D., Adomou A.C., Yédomonhan H., Tossou G.M., Akoègninou A.	Current and future distribution pattern of *Cochlospermum planchonii* and *Cochlospermum tinctorium* in Benin (West Africa), in response to climate change scenario	Modeling Earth Systems and Environment	2.83
14	Crop production	Aguégué M.R., Adjovi N.R.A., Agbodjato N.A., Noumavo P.A., Assogba S., Salami H., Salako K.V., Ramon R., Baba-Moussa F., Adjanohoun A., Glèlè Kakaï R., Baba-Moussa L.	Efficacy of Native Strains of Arbuscular Mycorrhizal Fungi on Maize Productivity on Ferralitic Soil in Benin	National Academy of Agricultural Sciences	0.99
15	Crop production	Aguégué R.M., Assogba S.A., Salami H.A.A., Koda A.D., Agbodjato N.A., Amogou O., Sina H., Salako K.V., Adjovi N.R.A., Dagbénonbakin G., Glèlè Kakaï R., Adjanohoun A., Baba-Moussa L.	Organic Fertilizer Based on Rhizophagus intraradices: Valorization in a Farming Environment for Maize in the South, Center and North of Benin	Frontiers in Sustainable Food Systems	3.95
16	Crop production	Anago F.N., Agbangba E.C., Oussou B.T.C, Dagbenonbakin G.D., Amadji L.G.	Cultivation of Cowpea Challenges in West Africa for Food Security: Analysis of Factors Driving Yield Gap in Benin	Agronomy	3.417
17	Ecophysiology	Sinsin C.B.L., Salako K.V., Fandohan A.B., Zanvo M.G.S., Kouassi K.E., Glèlè Kakaï R.	Pattern of seedling emergence and early growth in *Avicennia germinans* and *Rhizophora racemosa* along an experimental salinity gradient	African Journal of Ecology	1.426
18	Entomology	Dassou A.G., Idohou R., Azandeme-Hounmalon G.Y., Sabi-Sabi A., Houndété J., Silvie P., Dansi A.	Fall armyworm, *Spodoptera frugiperda* (J.E. Smith) in maize cropping systems in Benin: abundance, damage, predatory ants and potential control	International Journal of Tropical Insect Science	0.774
19	Ethnobotany	Odounharo O.G.R., Gnansounou S.C., Salako K.V., Idohou R., Mensah G.A., Glèlè Kakaï R., Assogbadjo A.E.	Medicinal use patterns of *Parkia biglobosa* (Jacq.) Benth. and Vitellaria paradoxa (Gaertn. F), two important traditional agroforestry species in Benin, West-Africa	Advances in Traditional Medicine	1.34
20	Ethnobotany	Biara E., Egeru A., Mensah S., Salamula J.B., Kadigo M.M.	Socio-economic factors influencing *Afzelia africana* Sm. use value and traditional knowledge in Uganda: implications for sustainable management	Environment, Development and Sustainability	3.219

N°	Discipline	Authors' Names	Title of the article	Journals	IF
21	Ethnobotany	Lokonon B.E., Sodoté F.E., Glèlè Kakaï R.	Use of local knowledge for contributing to the conservation of *Caesalpinia bonduc* (L.) Roxb in southern Benin (West Africa)	Global Ecology and Conservation	3.380
22	Ethnobotany	Houénon G.H.A., Djossou A.J., Kouhinkpo E.Y., Salako K.V., Tchobo F.P., Adomou A.C., Yédomonhan H.	Parataxonomy, perceived dynamics and diversity of uses of two Detarium species in Benin (West Africa)	Genetic Resources and Crop Evolution	1.524
23	Food security	Chadare F.J., Affonfere M., Sacla Aidé E., Fassinou F.K., Salako K.V., Pereko K., Deme B., Failler P., Glèlè Kakaï R., Assogbadjo A.E.	Current state of nutrition in West Africa and projections to 2030	Global Food Security	7.772
24	Forest ecology	Adjalla C., Tosso F., Salako K.V., Assogbadjo A.E.	Soil seed bank characteristics along a gradient of past human disturbances in a tropical semi-deciduous forest: Insights for forest management	Forest Ecology and Management	3.558
25	Forest estimations	Mensah S., van der Plas F., Noulèkoun F.	Do functional identity and divergence promote aboveground carbon differently in tropical semi-arid forests and savannas?	Ecosphere	3.171
26	Forest estimations	Panzou G.J.L., Fayolle A., Jucker T., Phillips O.L., Bohlman S., Banin L.F., Lewis S.L., Affum-Baffoe K., Alves L.F., Antin C., Arets E., Arroyo L., Baker T.R., Barbier N., Beeckman H., Berger U., Bocko Y.E., Bongers F., Bowers S., Brade T., Brondizio E.S., Chantrain A., Chave J., Compaore H., Coomes D., Diallo A., Dias A.S., Dimobe K., Djagbletey G.D., Domingues T., Doucet J-L., Drouet T., Forni E., Godlee J.L., Goodman R.C., Gourlet-Fleury S., Hien F., Iida Y., Ilondea B.A., Muledi J.I., Jacques P., Kuyah S., López-Portillo J., Loumeto J.J., Marimon-Junior B.H., Marimon B.S., Mensah S., Mitchard E.T. A., Moncrieff G.R., Narayanan A., O'Brien S.T., Ouedraogo K., Palace M.W., Pelissier R., Ploton P., Poorter L., Ryan C. M., Saiz G., dos Santos K., Schlund M., Sellan G., Sonke B., Sterck F., Thibaut Q., Hoef Y.V.,	Pantropical variability in tree crown allometry	Global Ecology and Biogeography	7.148

N°	Discipline	Authors' Names	Title of the article	Journals	IF
		Veenendaal E., Vovides A.G., Xu Y., Yao T.L., Feldpausch T.R.			
27	Forest estimations	Noulèkoun F., Birhane E., Mensah S., Kassa H., Berhe A., Gebremichael Z.M., Adem N.M., Seyoum Y., Mengistu T., Lemma B., Hagazi N., Abrha H.	Structural diversity consistently mediates species richness effects on aboveground carbon along altitudinal gradients in northern Ethiopian grazing exclosures	Science of the Total Environment	7.963
28	Natural resources management	Abdul-Kareem R., Gnansounou S.C., Adongo R.	Effects of the oil-find on land management in the Sekondi-Takoradi Metropolis, Western Coast of Ghana	Journal of Land Use Science	2.885
29	Natural resources management	Noulèkoun F., Birhane E., Kassa H., Berhe A., Gebremichael Z.M., Adem N.M., Seyoum Y., Mengistu T., Lemma B., Hagazi N., Abrha H., Rannestad M.M., Mensah S.	Grazing exclosures increase soil organic carbon stock at a rate greater than "4 per 1000" per year across agricultural landscapes in Northern Ethiopia	Science of the Total Environment	7.963
30	Natural resources management	Padonou E.A., Gbaï N.I., Kolawolé M.A., Idohou R., Toyi M.	How far are mangrove ecosystems in Benin (West Africa) conserved by the Ramsar Convention?	Land Use Policy	5.398
31	Natural resources management	Lokossou R.S., Akouèhou G.S., Akponikpè I.P.B., Davakan R., Glèlè Kakaï R., Ganglo J.	Integrated Soil Fertility Management to Address Food Security and Enhance Forest Ecosystems Sustainability in "Trois Rivières" Forest Reserves (Benin, West Africa)	Environmental Science and Engineering	0.280
32	Natural resources management	Noulèkoun F., Mensah S., Birhane E., Son Y., Khamzina A.	Forest Landscape Restoration under Global Environmental Change: Challenges and a Future Roadmap	Forests	2.116
33	Plant ecology	Atanasso J.A., Mensah S., Salako K.V., Tohoun R.J., Glèlè Kakaï R., Assogbadjo A.E.	Factors affecting survival of seedling of *Afzelia africana*, a threatened tropical timber species in West Africa	Tropical Ecology	0.850
34	Plant ecology	Atanasso J.A., Salako K.V., Mensah S., Tohoun R.J., Djossa B.A., Glèlè Kakaï R., Assogbadjo A.E.	Spatial distribution patterns of *Afzelia africana* (Fabaceae – Detarioideae) in a tropical savanna of Benin: implications for management	Plant Ecology and Evolution	1.366
35	Plant ecology	Luambua N.K., Hubau W., Salako K.V., Amani C., Bonyoma B., Musepena D., Rousseau M., Bourland N., Nshimba H.S.M, Ewango C., Beeckman H., Hardy O.J.	Spatial patterns of light-demanding tree species in the Yangambi rainforest (Democratic Republic of Congo)	Ecology and Evolution	2.91
36	Plant ecology	Sabo P., Ouédraogo A., Gbemavo D.S.J.C., Salako K.V., Glèlè Kakaï R.	Land use impacts on *Boswellia dalzielii* Hutch., an African frankincense tree in Burkina Faso	Bois et Forêts des Tropiques	0.692

N°	Discipline	Authors' Names	Title of the article	Journals	IF
37	Plant ecology	Zanvo M.S., Salako K.V., Gnanglé C., Mensah S., Assogbadjo A.E., Glèlè Kakaï R.	Impacts of harvesting intensity on tree taxonomic diversity, structural diversity, population structure, and stability in a West African mangrove forest	Wetlands Ecology and Management	1.379
38	Plant ecology	Compaoré S., Hounkpevi A., Zerbo I., Belemnaba L., Salako K.V., Gbemavo C., Ouedraogo S., Thiombiano A.	Impact of vegetation types on the floristic diversity, the availability and the ecological characteristics of five woody species stands used in the management of hypertension and diabetes in southern Burkina Faso	Environment, Development and Sustainability	3.219
39	Plant ecology	Lawin I.F., Salako K.V., Fandohan A.B., Assogbadjo A.E., Ouinsavi C.A.I.N.	Phénologie de *Cola millenii* K. Schum. au Bénin	Biotechnologie, Agronomie, Société et Environnement	1.087
40	Animal production	Kouato O.G., Houndonougbo V.P., Orounladji B.M., Chabi Adjobo M.A., Glèlè Kakaï R., Chrysostome C.A.A.M.	Comparative analysis of quantitative phenotypic parameters of Djallonke and hybrid (Djallonke Sahelian) goats in Benin	Journal of Animal & Plant Sciences	0.48

A1.5. Scientific papers published in peer-review indexed journals WIF in 2021

N°	Disciplines	Authors' Names	Title of the article	Journals
1	Forest sociology	Gnansounou S.C., Toyi M., Salako K.V., Ahossou D.O., Akpona T.J.D., Gbedomon R.C., Assogbadjo A.E., Glèlè Kakaï R.	Local uses of mangroves and perceived impacts of their degradation in Grand-Popo municipality, a hotspot of mangroves in Benin, West Africa	Trees, Forests and People
2	Crop production	Amogou O., Noumavo A.P., Agbodjato N.A., Sina H., Dagbénonbakin G., Adoko M.Y., Salako K.V., Glèlè Kakaï R., Adjanohoun A., Baba-Moussa L.	Rhizobacterial inoculation in combination mineral fertilizer improves maize growth and yield in poor ferruginous soil in central Benin	BioTechnologia. Journal of Biotechnology Computational Biology and Bionanotechnology
3	Agroforestry	Hounsou-Dindin G., Idohou R., Donou Hounsode M.T., Adomou A.C., Assogbadjo A.E., Glèlè Kakaï R.	Effects of seed provenance, pre-treatment and mass on germinability and seedling growth of *Balanites aegyptiaca* (L.) Delile and *Ricinodendron heudelotii* (Bail.) Pierre in Benin (West Africa)	Heliyon
4	Agricultural machinery	Dayou E.D., Zokpodo K.L.B., Atidegla C.S., Dahou M.N., Ajav E.A., Bamgboye A.I., Glèlè Kakaï R.	Analysis of the use of tractors in different poles of agricultural development in Benin Republic	Heliyon

A1.6. Scientific papers published in non-indexed peer-review journals in 2021

N°	Disciplines	Authors' Names	Title of the article	Journals
1	Agricultural machinery	Dayou E.D., Zokpodo B.K.L., Dahou N.M., Atidegla C.S., Ajav E.A., Bamgboye I.A., Glèlè Kakaï R.	Current status of agricultural cooperatives among the various users of agricultural machinery in Benin Republic	Bulletin de la Recherche Agronomique du Bénin (BRAB)
2	Agricultural machinery	Dayou E.D., Zokpodo K.L.B., Dahou N.M., Bamgboye A.I., Ajav E.A., Glèlè Kakaï R.	Overview of the use of pre-harvest equipment and typology of tractor users in Benin republic	Annales des sciences agronomiques
3	Sociology of natural resource management	El-hadj Issa A., Gbemavo D.S.J.C., Gbedomon R.C., Salako K.V., Mensah G.A., Sinsin B.A.	Structure et modèle de gouvernance de la Réserve Transfrontalière de Biosphère W du Bénin	Bulletin de la Recherche Agronomique du Bénin (BRAB)
4	Plant ecology	Lègba S.I., Assèdé E.S.P., Salako K.V., Sacla Aide E., Adomou C.A., Mensah G.A.	Effet des traitements et du substrat sur la germination et la croissance de sept espèces ligneuses d'importance socio-économique et médicinale au Bénin	Bulletin de la Recherche Agronomique du Bénin (BRAB)
5	Crop production	Wabi M.A., Vanhove W., Idohou R., Hounkpèvi A., Glèlè Kakaï R., Van Damme P.	Risques agro-météorologiques et production du riz pluvial (Oryza spp.) au Bénin	Science de la vie, de la terre et agronomie

A1.7. Books and book chapters in 2021

N°	Field of research	Authors' Name	Title	References
1	Biostatistics	Ojokoh B.A., Makinde O.S., Fayeun L.S., Babalola O.T., Salako K.V., Adzitey F.	Impact of COVID-19 and lockdown policies on farming, food security, and agribusiness in West Africa	Ojokoh B.A., Babalola O.S., Fayehun L.S, Makinde O.S., Salako K.V., Adzitey F. (2020). Impact of COVID-19 and lockdown policies on farming, food security and agribusiness in west African countries. In Data Science for COVID-19. Kose U., Gupta D., de Albuquerque V.H.C., Khanna A., (Editors). Volume 2: Societal and Medical Perspectives, Elsevier. Pp: 209 – 224.
2	Biostatistics	Ojokoh B.A., Sarumi O.A., Salako K.V., Gabriel A.J., Taiwo A.E., Johnson O.V., Adegun I.P, Babalola O.T.	Modeling and predicting the spread of COVID-19: a continental analysis	Ojokoh B.A Sarumi O.A., Salako K.V., Gabriel A.J., Taiwo A.E., Johnson O.V, Adegun I.P., Babalola O.T. (2020). Modelling and Predicting the Spread of COVID-19: A Continental Analysis. In Data Science for COVID-19. Kose U., Gupta D., de Albuquerque V.H.C., Khanna A., (Editors). Volume 2: Societal and Medical Perspectives. Academic Press. Pp: 299 – 318.

A1.8. Participation to conferences/seminars/workshops in 2021

N°	Title, Place and periode of the conference/seminar	Type of Presentation (oral, poster, ..)	Attendee
1	Ecophysiological response of *Avicennia germinans* (L.) L. and *Rhizophora racemosa* (G. Mey.) to the variation in groundwater salinity in Ouidah, Benin. Centre for African Wetlands, the University of Ghana. 1st and 2nd December 2021.	Oral	David Akodekou
2	Local uses of mangroves and perceived impacts of their degradation in Grand-Popo Municipality, a hotspot of mangrove in Benin, West-Africa. Centre for African Wetlands, the University of Ghana. 1st and 2nd December 2021	Oral	Constant Gnansounou
3	Salinity and human population density correlate fine-scale geographical distribution of mangroves and composite plant species in Benin, West Africa. Centre for African Wetlands, the University of Ghana. 1st and 2nd December 2021	Oral	Corine Sinsin
4	Mapping Spatio-temporal changes in mangroves cover and prediction of their future dynamics in Benin. Centre for African Wetlands, the University of Ghana. 1st and 2nd December 2021	Oral	Mahoutin G. S. Zanvo
5	Baobab leaves production for household consumption: a synthesis of existing techniques. Palais des Congres de Cotonou, Benin (online). 9th December 2021.	Oral	Guillaume Hounsou-Dindin
6	Geographic distribution and structural characterization of *Balanites aegyptiaca* (L.) Delile and *Ricinodendron heudelotii* (Bail.) Pierre along a climatic gradient in Benin (West Africa). Khenifra Superior School of Technology, Sultan Moulay Slimane University (SMS University) Morocco (online). 5th June 2021.	Oral	Guillaume Hounsou-Dindin
7	Establishing a technical guideline for agroecological production of baobab leaves at seedlings stage in Benin (West Africa). World Vegetable Centre, Simeon Road, Arusha, Tanzania (online). 25th and 28th January 2021.	Oral	Guillaume Hounsou-Dindin
8	A general strategy for setting up supervised methods of multiblock data analysis. 4ème Colloque scientifique international de l'Université de Kara.	Oral	
9	On the use of post-hoc tests in environmental and biological sciences: a critical review. 4ème Colloque scientifique international de l'Université de Kara.	Oral	
10	Diversity of agroforestry species and perception of their biofertilization potential in the Guinean-Congolese/Sudano-Guinean transition zone in Benin	Oral	Kakpo Angeline
11	Ecological niche modeling to identify potential areas for pineapple [*Ananas comosus* (l.) Merrill] cultivation in Benin under current and future climates. Journées Scientifiques du centre béninois de la recherche scientifique et de l'innovation & Journée de la renaissance scientifique de l'Afrique – Edition 2021	Oral	

APPENDIX 2.

Abstracts of published scientific papers in peer-review journals in 2021

Factors affecting survival of seedling of *Afzelia africana*, a threatened tropical timber species in West Africa

Atanasso J.A., Mensah S., Salako K.V., Tohoun R.J., Glèlè Kakaï R., Assogbadjo A.E.

Tropical Ecology, 62, 443–452 | **Impact Factor** $_{2020}$: 0.850
DOI : https://doi.org/10.1007/s42965-021-00160-7

Understanding abiotic and biotic factors affecting the survival of seedlings of threatened species such as *Afzelia africana* is fundamental for restoration and sustainable management purposes. This study used seedling individual-level morphological data and plot-level data to assess the effect of abiotic (season, elevation, soil type and terrain slope) and biotic (seedling initial density, basal diameter, height and number of leaves, insect and fungal infection, insect herbivory, mammal herbivory, vegetation type, adult conspecific density and diameter, and heterospecific density and diameter) factors on the survival probability (at individual level) and survival rate (at plot level) of seedlings of *A. africana* in the Pendjari Biosphere Reserve. Generalized Linear Mixed Models (GLMMs) were used for data analyses. At individual level, we found that the survival probability of *A. africana* seedlings increased initial height but decreased from wet to dry season. At plot level, the survival rate of *A. africana* seedlings also decreased from the wet season (0.72 ± 0.05) to the dry season (0.18 ± 0.04) and was inversely proportional to seedling basal diameter (P = 0.024) and density of conspecific adults (P = 0.016). There were also positive effects of seedling initial height (P = 0.026) and mean diameter of conspecific adults (P = 0.037) on survival rate. Among abiotic factors, only terrain slope showed a significant and negative effect (P = 0.028) on the survival rate, suggesting a higher survival rate on flat terrain. Our findings suggest that sustainably managing seedlings of *A. africana* would require accounting for conspecific neighboring effect, terrain slope and season-specific actions. Practical aspects of these factors were further discussed.

Keywords: *Afzelia africana*, Benin, Conspecific density, Pendjari Biosphere Reserve, Seedling-survival probability, Seedling-survival rate

Diversity in tree and fruit traits of *Strychnos spinosa* Lam. along a climatic gradient in Benin: a step towards domestication

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Genetic Resources and Crop Evolution, 68, 2423-2440 | **Impact Factor** $_{2020}$: 1.524
DOI: https://doi.org/10.1007/s10722-021-01140-5

Strychnos spinosa Lam. is an important wild edible fruit tree (WEFT) that is increasingly threatened due to anthropogenic pressure. Despite its remarkable socio-economic potential, commercial plantations for the species are rare. Characterization of the genetic diversity and potential of WEFT is a prerequisite for domestication and genetic improvement. This study assessed the morphological diversity and differentiation among populations of *S. spinosa* across a climatic gradient (Sudano-Guinean vs Sudanian zones) in Benin, West Africa. Morphological data were collected on 81 trees and 810 fruits of S. spinosa from 7 populations in the two climatic zones using nine phenotypic descriptors. Descriptive statistics and multivariate analyses were used to describe and partition differences among trees and study populations. Results showed highly significant differences (P B 0.001) among populations for all measured traits. The within-population variation accounted for the highest proportion (53–90%) of the total variation. Strong and positive correlations (r = 0.91–0.99; P\0.05) were observed among trunk and fruit traits except for tree height and fruits' seed weight, suggesting that fruit traits (fruit mass, pulp mass, seed number, ratio) can be predicted from trunk traits (dbh). Cluster analysis distinguished three distinct groups of S. spinosa in Benin. Population from Bassila phytodistrict in the Sudano-Guinean zone showed superior phenotypic traits (e.g., tree diameter, fruit mass, and pulp mass), indicating a high potential for selection for domestication purposes. Our study revealed marked phenotypic diversity of *S. spinosa* in Benin and provided relevant information for domestication and harnessing of *S. spinosa* genetic resources.

Keywords: Morphotypes, Agroforestry species, Domestication, *Strychnos spinosa*, Benin

Socio-economic factors influencing *Afzelia africana* Sm. use value and traditional knowledge in Uganda: implications for sustainable management

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Environment, Development and Sustainability, 23, 2261–2278 | **Impact Factor** $_{2020}$: 3.219
DOI: https://doi.org/10.1007/s10668-020-00673-6

Afzelia africana Sm. is a highly valued multi-purpose and overexploited tree species in Africa. Ethnobotany of *A. africana* can guide its sustainable usage, yet there is limited information on such aspect for the species in Uganda. Here, we assessed use values of *A. africana* and users' traditional knowledge and how they relate to plant parts and socioeconomic factors, including ethnicity, gender, education, age, marital status, profession, household size, income, land size and livestock ownership. Two hundred face-to-face semi-structured interviews were conducted. Use values were assessed based on plant part value (PPV) and use value per use category (UVk), while users' traditional knowledge was compared using overall use value (OUV) and reported use value (RUV). All plant parts were used, stem (PPV = 41.4%), seeds (19.6%) and leaves (19.3%) being the most important. Nine plant use categories were enumerated, most dominant being material (UVk = 0.63), followed by social (0.49) and fuel wood (0.41). Bark and root were mostly used for medicinal purpose, and branch and stem for fuelwood and material, respectively. Men and youngsters had higher OUV than females and older people, respectively. In particular, men frequently mentioned the use in agriculture, for fuelwood, environment and medicine, while women reported social use. Although the socio-cultural group did not influence significantly OUV and RUV, multivariate analyses revealed differentiation in use category according to socio-cultural group. Land size also predisposed informants to report more uses for the species. Taking these significant socio-economic factors into account in participative forest management will facilitate *A. africana* sustainable use.

Keywords: Ethnobotany, Socio-cultural group, Multi-purpose tree species, Gender, Traditional knowledge, Uganda

Fall armyworm, *Spodoptera frugiperda* (J.E. Smith) in maize cropping systems in Benin: abundance, damage, predatory ants and potential control

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International Journal of Tropical Insect Science, 41, 2627 -2636 | **Impact Factor** $_{2020}$: 0.774
DOI : https://doi.org/10.1007/s42690-021-00443-5

Invasive fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae), is a species native to the Americas which has spread to Africa in 2016. This insect has been reported in Benin as a major pest of maize causing important economic losses and putting at risk food and nutritional security. This study evaluated the damage caused by this pest to maize in different cropping system and management practices. It also assessed predatory ants presence and diversity and their potential in controlling FAW. Results showed that 50% of farmers grow maize in a mixed cropping systems in association sorghum, cassava and cowpea and also used biopesticides. FAW larval population and damage in maize fields varied accros villages. Surprinsingly FAW larval population was higher in maize field sprayed insecticides than untreated field. Seven species of predatory ants were recorded in maize field. Ants' population was higher in untreated field (1043 ants per hectare) than treated field (806 ants per hectare). In the laboratory, ants species exhibits great predatory potential. Further studies are needed to discuss uses of ants in FAW management in Benin.

Keywords: Invasive species, Africa, Predation, Infestation, Pest, Ants

Current status of agricultural cooperatives among the various users of agricultural machinery in Benin Republic

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Some farmers regroup themselves into Cooperative of agricultural machinery use (CUMA) in order to reduce the hardness of farming operations and to face the financial problems of agricultural mechanization. The objective of the study was to assess the current status of agricultural cooperatives among the various users of agricultural machinery in Benin Republic. A total of 203 people included 30 CUMAs were surveyed in all the country. The sample size was determined using the normal approximation of binominal distribution sampling method. Each respondent was interviewed using a structured questionnaire. Data were analyzed using descriptive statistics such as tables and figures. The data were also subjected to a Hierarchical Classification on Main Components. Recursive partitioning was carried out to describe the groups of tractor users. From four groups of tractor users identified, the group of CUMA represented 15.59%. Globally the number of CUMAs' members was around 7 persons per CUMA but depend on the sex. Males were more represented than females. Some CUMA equipped (85%). About 93.33% of cooperative members were older than 40 years. However, only 40% attended secondary school level. More of them had agriculture as main activity (86.67%), but 13.33% work in other sector (livestock) before earn their breads. Among the 14 marks of tractor identified in Benin, six were used in the cooperatives. Most of tractors had an average power of 60 horsepower and many of them had less than 10 years of use. The marks Farmtrac and Sonalika were the most used (40%) of each of them. Maize and cotton are the most important crops mechanized by cooperative farmers. The average area mechanized in CUMA was 170.27 ha/year against a tillage cost of 30,300 FCFA/ha. The results call for innovation to support CUMAs and help poor farmers to get equipment.

Keywords: cooperative, tractor, agriculture, mechanization, Benin Republic.

Analysis of the use of tractors in different poles of agricultural development in Benin Republic

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The deep assessment of agricultural mechanization inside developing countries could help for local action-taking. This study investigates the use of tractors between the poles of agricultural development (PAD) in Benin Republic. Using a multi-stage random sampling procedure and a questionnaire, 203 tractor users were surveyed in 43 municipalities distributed across the seven PADs of the country. Kruskal-Wallis tests were carried out to compare the different poles of agricultural development based on the mechanization level and tractor performances. Student-Newman-Keuls tests were used to structure the means of these variables. The results show a significant variation ($P < 0.05$) of the mechanization level between the PADs. Apart PAD1, all the poles use greater than 60 % manual equipment. Animal-drawn is most implemented in the northern part of the country (PAD1; 2 and 3). The use of tractors is lower over the country, and the PAD2 and PAD3 are the most users. From PAD4 to PAD7, the combination of manual tillage animal power or tractor is not well represented, indicating manual tillage-based agriculture in these poles. In general, 53.20% of the users do not have a tractor parking and the repair center is quasi-absent (97.54 %). PAD2; 4 and 3 are most disc plow users. Mechanical sowing is more observed in PAD2 and 7 and absent in PAD1; 3 and 4. Moreover, the harvester is present in PAD2; 4; 6, and 7. On average, the highest mechanized area was 134.56 ha from PAD3, whereas the lowest, 12.00 ha was found in PAD7. PAD7 spends more on plowing (47670 FCFA) than the other poles. The mechanized plowing is slower in PAD7 (3.53 h/ha) while much faster at the PAD2 (1.96 h/ha). These results could help decision-makers for accurate actions taking to advocate for agricultural mechanization sectors in the country based on the weakness of each pole of agricultural development.

Keywords: Machinery use, Tractor performances, Local development, Mechanization level Benin

Current and future distribution pattern of *Cochlospermum planchonii* and *Cochlospermum tinctorium* in Benin (West Africa), in response to climate change scenario

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Cochlospermum tinctorium and *Cochlospermum planchonii* highly contribute to complementary diet, health care, monetary income, and livelihood security across rural communities of West African countries as Benin. Though, facing the environmental impacts of climate change, several plants species, of which Cochlospermum species population are expected to be threatened, losing their native habitats. Using Maximum Entropy (MaxEnt) algorithm, both Cochlospermum species were modeled to estimate their potential distribution pattern under current and future climate change scenarios in Benin under the scenarios RCP 4.5 and 8.5, by horizon-time 2055. Overall, 535 and 644 occurrence records were used to run the model using cross-validation method and Write background predictions five replicated times. The performance and accuracy of the model were checked through an area under curve (AUC) which were around 0.86 and 0. 91 and TSS values about 0.6 and 0.53, respectively, for *C. tinctorium* and *C. planchonii*. Within the five bioclimatic variables retained for each species, the number of dry months (DM) 51.3% and the annual moisture index (MI) 46.3% contributed the most to the distribution modelling. Currently, about 66 and 36% of the area of Benin, 62 and 52% of the protected areas were of high suitability, respectively, for *C. planchonii* and *C. tinctorium*. RCPs 4.5 and 8.5 scenarios forecast an expansion in future distribution, respectively, for *C. planchonii* (7.91 and 10%) and *C. tinctorium* (2.49 and 4.81%). Though, these results highlight the climate change impacts on Cochlospermum species distribution in Benin, further studies are needed to assess their abundance, conservation status and threats.

Keywords: Benin, *Cochlospermum* spp., Conservation, Maxent, Ecological niche modelling

Pantropical variability in tree crown allometry

Panzou G.J.L., Fayolle A., Jucker T., Phillips O.L., Bohlman S., Banin L.F., Lewis S.L., Affum-Baffoe K., Alves L.F., Antin C., Arets E., Arroyo L., Baker T.R., Barbier N., Beeckman H., Berger U., Bocko Y.E., Bongers F., Bowers S., Brade T., Brondizio E.S., Chantrain A., Chave J., Compaore H., Coomes D., Diallo A., Dias A.S., Dimobe K., Djagbletey G.D., Domingues T., Doucet J-L., Drouet T., Forni E., Godlee J.L., Goodman R.C., Gourlet-Fleury S., Hien F., Iida Y., Ilondea B.A., Muledi J.I., Jacques P., Kuyah S., López-Portillo J., Loumeto J.J., Marimon-Junior B.H., Marimon B.S., Mensah S., Mitchard E.T. A., Moncrieff G.R., Narayanan A., O'Brien S.T., Ouedraogo K., Palace M.W., Pelissier R., Ploton P., Poorter L., Ryan C. M., Saiz G., dos Santos K., Schlund M., Sellan G., Sonke B., Sterck F., Thibaut Q., Hoef Y.V., Veenendaal E., Vovides A.G., Xu Y., Yao T.L., Feldpausch T.R.

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DOI **:** https://10.1111/geb.13231

Aim: Tree crowns determine light interception, carbon, and water exchange. Thus, understanding the factors causing tree crown allometry to vary at the tree and stand level matters greatly for the development of future vegetation modelling and for the calibration of remote sensing products. Nevertheless, we know little about large-scale variation and determinants in tropical tree crown allometry. In this study, we explored the continental variation in scaling exponents of site-specific crown allometry and assessed their relationships environmental and stand-level variables in the tropics. *Location*: Global tropics. Time period: Early 21st century. Major taxa studied: Woody plants. *Methods*: Using a dataset of 87,737 trees distributed among 245 forest and savanna sites across the tropics, we fitted site-specific allometric relationships between crown dimensions (crown depth, diameter, and volume) and stem diameter using power-law models. Stand-level and environmental drivers of crown allometric relationships were assessed at pantropical and continental scales. *Results:* The scaling exponents of allometric relationships between stem diameter and crown dimensions were higher in savannas than in forests. We identified that continental crown models were better than pantropical crown models and that continental differences in crown allometric relationships were driven by both stand-level (wood density) and environmental (precipitation, cation exchange capacity and soil texture) variables for both tropical biomes. For a given diameter, forest trees from Asia and savanna trees from Australia had smaller crown dimensions than trees in Africa and America, crown volumes for some Asian forest trees being smaller than those of trees in African forests. *Main conclusions*: Our results provide new insight into geographical variability, large continental differences in tropical tree crown allometry that were driven by stand-level and environmental variables. They have implications for the assessment of ecosystem function and for the monitoring of woody biomass by remote sensing techniques in the global tropics.

Keywords: crown allometry, environment, forest, precipitation, savanna, soil, stand-level variable, tropical biomes

Local uses of mangroves and perceived impacts of their degradation in Grand-Popo municipality, a hotspot of mangroves in Benin, West Africa

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Detailed understanding of interactions between humans and their surrounding ecosystems is essential for designing sustainable use and management of these ecosystems. Mangroves are one of the most productive ecosystems worldwide, yet amongst the most threatened. This study (1) explored main activities of local communities in relationship to mangroves and variation across geographical locations, gender, and age categories, (2) investigated plants and animals used and collected from mangroves and their adjacent areas, and (3) assessed local perception on the impacts of their activities on the degradation of mangroves and potential effects of this degradation on their life attributes (security, income, health and culture). The study was conducted in Grand-Popo municipality, a hotspot of mangroves and the only one coastal municipality embedded in the Mono Transboundary Biosphere Reserve in Benin. Data were collected through individual interviews (n = 360) in nine villages of the municipality. Results showed that local communities of Grand-Popo practice nine income generating activities (IGA) within mangroves and fishing (31.65%), wood collection (22.73%), *Cyperus articulatus* collection (21.67%), medicinal plant collection (8.98%), and salt production (5.56%) were frequent. There were important differences across geographical locations, gender, and age categories regard to used mangrove resources and socio-economic activities. Respondents reported twenty-three fish species, two shrimp species, two crab species and one oyster species as fishery resources commonly collected from mangroves. Most interviewees (58.33%) believed that their activities do not negatively impact mangroves despite popular recognition of the dwindling of mangroves' coverage (75% of respondents). Our findings provide important information on resources collected and used in mangrove ecosystems and highlight strong geographical locations, gender, and age categories variation. Implications for sustainable participative management were discussed.

Keywords: Mangroves, *R. racemosa*, *A. germinans*, Grand-Popo, Mono transboundary biosphere reserve Benin

On the reliability of predictions on Covid-19 dynamics: A systematic and critical review of modelling techniques

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Since the emergence of the novel 2019 coronavirus pandemic in December 2019 (COVID- 19), numerous modellers have used diverse techniques to assess the dynamics of transmission of the disease, predict its future course and determine the impact of different control measures. In this study, we conducted a global systematic literature review to summarize trends in the modelling techniques used for Covid-19 from January 1st, 2020 to November 30th, 2020. We further examined the accuracy and precision of predictions by comparing predicted and observed values for cumulative cases and deaths as well as uncertainties of these predictions. From an initial 4311 peer-reviewed articles and preprints found our defined keywords, 242 were fully analysed. Most studies were done on Asian (78.93%) and European (59.09%) countries. Most of them used compartmental models (namely SIR and SEIR) (46.1%) and statistical models (growth models and time series) (31.8%) while few used artificial intelligence (6.7%), Bayesian approach (4.7%), Network models (2.3%) and Agent-based models (1.3%). For the number of cumulative cases, the ratio of the predicted over the observed values and the ratio of the amplitude of confidence interval (CI) or credibility interval (CrI) of predictions and the central value were on average larger than 1 indicating cases of inaccurate and imprecise predictions, and large variation across predictions. There was no clear difference among models used for these two ratios. In 75% of predictions that provided CI or CrI, observed values fall within the 95% CI or CrI of the cumulative cases predicted. Only 3.7% of the studies predicted the cumulative number of deaths. For 70% of the predictions, the ratio of predicted over observed cumulative deaths was less or close to 1. Also, the Bayesian model made predictions closer to reality than classical statistical models, although these differences are only suggestive due to the small number of predictions within our dataset (9 in total). In addition, we found a significant negative correlation (rho = - 0.56, p = 0.021) between this ratio and the length (in days) of the period covered by the modelling, suggesting that the longer the period covered by the model the likely more accurate the estimates tend to be. Our findings suggest that while predictions made by the different models are useful to understand the pandemic course and guide policy-making, some were relatively accurate and precise while other not.

Keywords: Predictions, Accuracy, Precision, SARS-CoV-2 Pandemic Ratio

Comparative analysis of quantitative phenotypic parameters of Djallonke and hybrid (Djallonke × Sahelian) goats in Benin

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The characterization of small ruminants in developing countries would play an important role in the conservation of animal genetic resources. This study aimed to identify and characterize indigenous goats in the districts of Kouandé, Kérou, and Péhunco (2KP) in Benin. A sample of 826 goats aged up to 3 years old was studied considering 18 quantitative traits: live weight, heart girth, height at withers, rump height, body length, pin-bone length, pin-bone width, neck girth, chest depth, shoulder length, tail length, ear length, head length and width, horn length and shinbone circumference. Multivariate analyses (Principal Component Analysis and Multivariate Analysis of Variance) revealed that goat population had two morphological subtypes. The breeds identified were dwarf goats middle size (44.17 ± 7.51 cm for height at withers and 45.73 ± 7.54 cm for rump height) ears (9.71 ± 1.37 cm for the left ear and 9, 57 ± 1.26 cm for the right ear) and short horns (5.3 ± 2.29 cm for the left horn and 5.34 ± 2.28 cm for the right horn). Djallonké × Sahelian had a large size (53.49 ± 8.12 cm for height at withers and 54.59 ± 8.13 cm for rump height). Their ears showed 11.69 ± 1.27 cm for the left and 11.6 ± 1.27 cm for the right longhorns (9.73 ± 3.02 cm for the left horn and 9.62 ± 3.06 cm for the right horn). A multivariate analysis of the variance also showed that there is a highly significant difference ($p < 0.001$) between the two breeds as regards biometric parameters. The present study could greatly help in designing management and conservation policies for the sustainable production of goat breeds in Benin.

Keywords: breeds, goat, quantitative traits, Benin

Morphological variability of fruits of *Cola millenii* K. Schum. from seven phytogeographical districts in Benin: opportunity for domestication

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Genetic Resources and Crop Evolution, 68, 1225-1242 | **Impact Factor** $_{2020}$: 1.524
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Cola millenii K. Schum. is a wild edible fruit tree of high socio-economic importance in Sub-Sahara Africa. Its fruit pulp is used for food and nutritional purposes. Other parts of the tree are locally used against several diseases. Given the current threats to natural stands of this species, its domestication has been suggested as one of the methods for its sustainable management. The present study analyzed the domestication potential of this species through evaluation of morphological variability of its fruits across seven phytogeographical districts in Benin. Morphological data on fruits were collected on 1750 fruits from 175 trees distributed among the phytogeographical districts. Univariate and multivariate statistical methods were used for data analyses. The morphological traits of the fruits varied significantly among the phytogeographical districts. Among others, the weight of the pulp fluctuated between 4.18 and 15.55 g and the Bassila phytogeographical district presented the highest value. Variation in quantitative traits was greater between phytogeographical districts (55.44–89.13%) than among individuals within phytogeographical districts (9.52–34.32%). Qualitative descriptors such as shape and the color of the fruits and seeds also unfolded noticeable variation among phytodistricts (Shannon diversity: 0.14–1.46). However, there was no evidence of significant link between the morphological characteristics and the climatic variables considered (rainfall, relative humidity, minimum temperature and maximum temperature). Clustering suggested three fruit morphotypes. Fruits of morphotype 3, in majority from the Bassila and Zou phytogeographical districts had interesting characteristics (e.g., high fruit and pulp weight, and large fruit and seed size) for selection programs.

Keywords: *Cola millenii*, Quantitative descriptors, Qualitative descriptors, Morphotype, Canonical discriminating analysis, West Africa

Use of local knowledge for contributing to the conservation of *Caesalpinia bonduc* (L.) Roxb in southern Benin (West Africa)

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Natural resources such as medicinal plants are important in the livelihood systems of many local people around the world. The high anthropogenic pressure on these species lead to their progressive disappearance. This is the case of *Caesalpinia bonduc*, a medicinal plant widely used in southern Benin but already extinct in the wild. The remaining individuals can only be found in agroforestry systems and home gardens. Therefore, it is necessary to assess the factors responsible of the decline of the species for its sustainable conservation. This study aimed to assess traditional knowledge, perceptions and strategies for an effective management of the species in southern Benin. A semi-structured interview was conducted 602 household heads randomly chosen from 19 localities. The fidelity level (FL), index value related to useful organs (IVO) and overall ethno-botanical use value (OUV) of the species were estimated. To describe ethnic groups-related differences, a principal component analysis (PCA) was implemented on OUV. Chi-Square test was used to check the dependence between socio-demographical characteristics of the respondents and local perceptions and strategies. A factorial correspondence analysis (FCA) was then performed on the citation frequencies of different variables to describe the relationship between ethnic groups and local perceptions and strategies. In total, 20 use properties were reported for the species 10 previously undocumented uses of the species. The roots are the most used organ IVO=50%, followed by the leaves (IVO=45%). The species is most used in traditional human medicine (FL=100%). A strong relationship was found between ethnic groups and use of the species but also between ethnic groups and perceptions and management strategies. Respondents acknowledged that the species has decreased (80% of them) and even has disappeared (18%) in the wild. According to the informants, the main causes of the decline of the species are roots overexploitation (53.7%), intensive use in traditional pharmacopoeia (37%) and agriculture expansion (32.6%). Respondents also acknowledged that there is an urgent need for the species conservation (96%). Reduce intensity of harvesting plant parts, cultivating the species in nurseries, planting and protecting seedlings in fields were cited as methods of conserving the species. This study provides a precious contribution to the conservation of *C. bonduc* in southern Benin. Therefore, we recommend for any actions aiming to rehabilitate the species in its natural stands, local people' priorities and knowledge should be considered.

Keywords: Medicinal plant, local knowledge, conservation strategies, perceptions, cultural groups, southern Benin

Structural diversity consistently mediates species richness effects on aboveground carbon along altitudinal gradients in northern Ethiopian grazing exclosures

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Grazing exclosures have been promoted as an effective and low-cost land management strategy to recover vegetation and associated functions in degraded landscapes in the tropics. While grazing exclosures can be important reservoirs of biodiversity and carbon, their potential in playing a dual role of conservation of biodiversity and mitigation of climate change effects is not yet established. To address this gap, we assessed the effect of diversity on aboveground carbon (AGC) and the relative importance of the driving biotic (functional diversity, functional composition and structural diversity) and abiotic (climate, topography and soil) mechanisms. We used a dataset from 133 inventory plots across three altitudinal zones, i.e., highland, midland and lowland, in northern Ethiopia, which allowed local- (within altitudinal zone) and broad- (across altitudinal zones) environmental scale analysis of diversity-AGC relationships. We found that species richness-AGC relationship shifted from neutral in highlands to positive in mid- and lowlands as well as across the altitudinal zones. Structural diversity was consistently the strongest mediator of the positive effects of species richness on AGC within and across altitudinal zones, whereas functional composition linked species richness to AGC at the broad environmental scale only. Abiotic factors had direct and indirect effects via biotic factors on AGC, but their relative importance varied altitudinal zones. Our results indicate that the effect of species diversity on AGC was altitude dependent and operated more strongly through structural diversity (representing niche complementarity effect) than functional composition (representing selection effect). Our study suggests that maintaining high structural diversity and managing functionally important species while promoting favourable climatic and soil conditions can enhance carbon storage in grazing exclosures.

Keywords: Functional traits, Selection effects, Niche complementarity, Structural diversity, Environmental gradients, Structural equation modelling

Forest Landscape Restoration under Global Environmental Change: Challenges and a Future Roadmap

Noulèkoun F., Mensah S., Birhane E., Son Y., Khamzina A.

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The adverse impacts of ecosystem degradation have raised the need for forest landscape restoration (FLR) to be included in international sustainability agendas. However, the path towards successful FLR implementation faces numerous biophysical, socioeconomic and governance challenges because FLR operates within complex socioecological systems. In the present study, we review and discuss FLR challenges in the context of global environmental change. We propose a roadmap consisting of five interlinked steps to overcome these challenges: (1) advancing ecological knowledge supporting FLR, (2) adapting FLR management to environmental change through strengthening globally distributed experimental networks, (3) implementing modelling approaches, (4) improving socioeconomic and governance dimensions, and (5) developing evidence-based knowledge platforms. The roadmap offers an iterative and adaptive framework for the continuous evaluation and improvement of FLR strategies and outcomes.

Keywords: environmental change, evidence-based platform, functional restoration, participatory monitoring, silvicultural management

Coconut-gliricidia mixed cropping systems improve soil nutrients in dry and wet regions of Sri Lanka

Raveendra S.A.S.T., Nissanka S.P., Somasundaram D., Atapattu A.J., Mensah S.

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DOI : https://doi.org/10.1007/s10457-020-00587-2

Agroforestry systems are alternative solutions for production and management of agricultural systems which may improve soil quality. In this study, we evaluated the potential of coconut Cocos nucifera based Gliricidia (*Gliricidia sepium*) systems to improve soil quality of coconut lands in Sri Lanka in dry and wet regions. A three-year field experiment was conducted in a randomized complete block design three treatments T0, T5 and T20, being respectively the control, five and twenty years aged Gliricidia intercropped coconut-based mixed systems. Three replicates of soil samples were taken at 0–15, 15–30 and 30–45 cm and differences in soil physical and chemical properties were evaluated among treatments and sites. We found significant effects of mixed system treatments on the soil chemical properties. In particular, organic matter, soil exchangeable potassium, total nitrogen and available phosphorus contents showed higher values in most coconut-gliricidia mixed systems' soils, highest values obtained for T20. Cumulatively for all soil depths, organic matter content (22%) and available phosphorus content (20%) were higher on the wet site, and total exchangeable potassium content (69%) higher on the dry site for T20. The pH, bulk density, microbial respiration and electric conductivity did not vary among treatments, but were influenced by the site characteristics, the dry site showing higher values for pH and the wet site showing higher values for bulk density (5%), microbial respiration (33%) and electric conductivity (2%) in T20 treatment. The study demonstrates that the systems Gliricidia differed in their soil chemical attributes and had higher levels of soil nutrients when compared to coconut monocrop even at early ages, underlying the potential of Gliricidia for the rehabilitation of coconut growing soils.

Keywords: Agroforestry, *Gliricidia sepium*, Intercropping systems, Monoculture, Soil rehabilitation

On the Discretization of Continuous Probability Distributions Using a Probabilistic Rounding Mechanism

Tovissodé C.F., Honfo S.H., Doumatè J.T., Glèlè Kakaï R.

Mathematics | **Impact Factor** $_{2020}$: 1.747
DOI : https://doi.org/10.3390/math9050555

Most existing flexible count distributions allow only approximate inference when used in a regression context. This work proposes a new framework to provide an exact and flexible alternative for modeling and simulating count data various types of dispersion (equi-, under-, and overdispersion). The new method, referred to as "balanced discretization", consists of discretizing continuous probability distributions while preserving expectations. It is easy to generate pseudo random variates from the resulting balanced discrete distribution since it has a simple stochastic representation (probabilistic rounding) in terms of the continuous distribution. For illustrative purposes, we develop the family of balanced discrete gamma distributions that can model equi-, under-, and over-dispersed count data.

This family of count distributions is appropriate for building flexible count regression models because the expectation of the distribution has a simple expression in terms of the parameters of the distribution. Using the Jensen–Shannon divergence measure, we show that under the equidispersion restriction, the family of balanced discrete gamma distributions is similar to the Poisson distribution. Based on this, we conjecture that while covering all types of dispersions, a count regression model based on the balanced discrete gamma distribution will allow recovering a near Poisson distribution model fit when the data are Poisson distributed.

Keywords: flexible count models, balanced gamma distribution, Jensen–Shannon divergence, latent equidispersion

Impacts of harvesting intensity on tree taxonomic diversity, structural diversity, population structure, and stability in a West African mangrove forest

Zanvo M.S., Salako K.V., Gnanglé C., Mensah S., Assogbadjo A.E., Glèlè Kakaï R.

Wetland Ecology Management, 29(3), 433-450 | **Impact Factor** $_{2020}$: 1.379
DOI : https://doi.org/10.1007/s11273-021-09793-w

Understanding the impacts of wood harvesting intensity on the diversity and structure of ecosystems such as mangroves is essential for defining actions for their sustainable management. We compared tree taxonomic diversity, structural diversity and dominance patterns, density, growth characteristics, size class distribution-SCD and stand stability in West African mangroves subject to low vs. high wood harvesting intensity. Data on tree species identity, total height, diameter (dbh), and conditions (logged, topped or pruned) were collected from ten mangrove sites per harvesting intensity. We found seven species of which two true mangroves species (*Rhizophora racemosa* and *Avicennia germinans*) that were dominant across all sites. As expected, there were significantly 3–4, 3–7, and 2–4 times more logged, topped and pruned trees respectively in high-harvesting sites than in low harvesting sites. Taxonomic diversity was less affected than structural diversity (dbh and height-based diversity metrics). Tree density was significantly 1.3–5 times higher in low-harvesting sites than in high-harvesting sites for the whole stand and each of the dominant species. Total regeneration density was also low in high-harvesting sites. However, regeneration density was relatively higher in high-harvesting sites for *R. racemosa* contrary *to A. germinans*. Trees were also significantly smaller and shorter in high-harvesting sites. The SCD indicated inverse J-shaped distributions, irrespective of the harvesting intensity and showed that tree harvesting targeted mostly dbh classes 10–30 cm. The density of this class was 2.6–6.2 times lower in high-harvesting sites. This study provides important information on impacts of wood harvesting in a marginally studied mangroves' area.

Keywords: Anthropogenic activities, Tree diversity and structure, Mangroves, Rhizophora, Avicennia, Benin

Cultivation of Cowpea Challenges in West Africa for Food Security: Analysis of Factors Driving Yield Gap in Benin

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Agronomy, 11(6), 1139 | **Impact Factor** $_{2020}$: 3.417
DOI: https://doi.org/10.3390/agronomy11061139

Feeding the world in 2050 requires us to find ways to boost yields of the main local crops. Among those crops, cowpea is one of the grain legumes that is playing an important role in the livelihood of millions of people in West Africa, especially in Benin. Unfortunately, cowpea on-farm yields are very low. In order to understand the main factors explaining cowpea yield gaps, we collected and analyzed detailed survey data from 298 cowpea fields in Benin during the 2017, 2018 and 20190 s rainy seasons, respectively. Composite soil samples were collected from cowpea fields and analyzed in the laboratory. Data on farm field management practices and field conditions were recorded through interviews 606 farmers. Average cowpea grain yields were low and seldom surpassed 700 kg /ha on farmer's fields. Significant differences were observed between cowpea grain yields from northern to southern Benin ($p < 0.05$), and the lowest yields were observed in northern Benin. These low yields are related to crop management practices, soil nutrient contents, and the interaction of both. According to the model of regression tree from northern to southern Benin, the use of mineral fertilizer, insecticide sprays to control pests, and the improvement of phosphorus, nitrogen, potassium (P, N, K) and cation sum content in the topsoil would increase cowpea grain yields. Insect pests, diseases, and soil fertility decline are the largest constraints limiting grain yield in Benin. Future research should focus on formulating site-specific fertilizer recommendations for effective cowpea cultivation in Benin, as well as the control of insect pests and diseases.

Keywords: food security, soil fertility, crop management practices, cowpea yield

Impact of vegetation types on the floristic diversity, the availability, and the ecological characteristics of five woody species stands used in the management of hypertension and diabetes in southern Burkina Faso

Compaoré S., Hounkpevi A., Zerbo I., Belemnaba L., Salako K.V., Gbemavo C., Ouedraogo S., Thiombiano A.

Environment, Development and Sustainability, 24(1), 683-700 | **Impact Factor** $_{2020}$: 3.219
DOI: https://doi.org/10.1007/s10668-021-01463-4

The use of modern drugs to manage hypertension and diabetes is enough expensive and requires constant monitoring of the patient due to the chronicity and complications of these diseases. Thus, the populations of southern Burkina Faso have opted for the use of plants, including *Parkia biglobosa* (Jacq.) R.Br. ex G. Don, *Sclerocarya birrea* (A. Rich.) Hochst, *Lannea acida* A. Rich, *Lannea microcarpa* Engl. & K. Krause and *Balanites aegyptiaca* (L.) Delile. To better contribute to preserving these fve target species, the present study analyses the foristic diversity of the diferent vegetation types in which they occur, assesses their availability and determines the health status of their stands. To achieve this, a foristic inventory was conducted in 109 plots, including 26 plots of 500 m2 in riparian forests, 22 of 2500 m2 in fallows 31, 18 and 12 of 1000 m2 in tree savannahs, shrub savannahs and fenced areas, respectively. The diameter at breast height (dbh) of each individual of the target species was measured in each plot and its health status assessed. Results showed that species diversity varied signifcantly among vegetation types. According to the Shannon index, riparian forests were the most diversifed (H=2.62±0.02 bits). *Lannea microcarpa, Lannea acida, Sclerocarya birrea,* and *Balanites aegyptiaca* were very frequent (Ri≤60) to moderately frequent (60<R<80) within vegetation types. The vitality of their stands was independent of vegetation types. However, their individuals were weakly attacked in the fenced areas indicating that local people control these ecosystems. Fenced areas strategies appear to be alternative solutions to preserve stands of species that are an mostly high priority for populations.

Keywords: Woody vegetation, Sustainable preservation, Hypertension, Diabetes

Parataxonomy, perceived dynamics and diversity of uses of two *Detarium* species in Benin (West Africa)

Houénon G.H.A., Djossou A.J., Kouhinkpo E.Y., Salako K.V., Tchobo F.P., Adomou A.C., Yédomonhan H.

Genetic Resources and Crop Evolution, 68(6), 2627-2654 | **Impact Factor** $_{2020}$: 1.524
DOI: https://doi.org/10.1007/s10722-021-01169-6

The contribution of species providing nontimber forest products to the livelihoods of local communities is well established. However, this contribution may be limited by the existence of confusion while dealing close relative species. This is particularly the case for *Detarium microcarpum* Guill & Perr. and *D. senegalense* J.F.Gmel. The objectives of this study were to (1) identify the criteria used by local communities to differentiate *D. microcarpum* and *D. senegalense*, (2) determine local communities' perception of the past dynamics of the two species and (3) assess the diversity of uses of both species. Data on differentiation criteria, perceived variation in the species abundance, and the different uses were collected using individual semi-structured interviews (n = 914 informants). The relative frequency of citation and the use-value were calculated. The Chi- square test, correspondence analysis and generalized linear model were used for statistical analyses. Informants used fourteen criteria to differentiate the two species. The predominant criteria were the shape of the seed (87.86%) and the shape of the fruit (67.86%). Most of the informants reported that the populations of *D. microcarpum* (61.80%) and that of *D. senegalense* (60.12%) have regressed. In total, 168 use reports were enumerated for the two species 19 shared use-reports. We concluded that local communities use a variety of criteria to differentiate both species, the most popular being morphological traits of the fruits. Both species shared several use-reports (11.31%). However, their populations have declined. The documented uses for both species provide preliminary information for their future food uses and drug discovery.

Keywords: *Detarium* spp., Local taxonomy, Threats, Ethnobotany, Benin

Phénologie de *Cola millenii* K. Schum. au Bénin

Lawin I.F., Salako K.V., Fandohan A.B., Assogbadjo A.E., Ouinsavi C.A.I.N.

Biotechnologie, Agronomie, Société et Environnement, 25(3), 161-171 | **Impact Factor** $_{2020}$: 1.087
DOI : https://doi.org/10.25518/1780-4507.19095

Description du sujet. La compréhension des facteurs influençant les phénophases des plantes d'importance socio-économique est essentielle pour leur gestion durable. *Cola millenii* est un arbre dont les fruits sont comestibles. Objectifs. La présente étude a analysé les différentes phénophases de l'espèce le long d'un gradient climatique au Bénin. Méthode. Les évènements de feuillaison, floraison et fructification ont été observés au milieu et à la fin de chaque mois (environ chaque 15 jours) durant deux ans dans huit phytodistricts distribués entre la zone guinéenne et la zone soudanoguinéenne du Bénin. Résultats. Dans les deux zones climatiques, *C. millenii* porte des feuilles toute l'année, mais l'intensité de la feuillaison varie au cours de l'année. On observe une forte chute de feuilles de janvier à mars. *Cola millenii* fleurit d'octobre à avril (saison sèche). Un décalage d'un mois a été observé dans le phytodistrict du Borgou-Sud où la floraison a démarré en novembre. Le pic de la floraison a été constaté en décembre. La fructification s'étend de novembre (nouaison) à juillet (saison sèche à mi-saison pluvieuse). Un décalage d'un mois a été également observé dans le phytodistrict du Borgou-Sud où la fructification a démarré en décembre. Le pic de fructification a été observé dans la période de février à juillet. Les fruits murissent de façon progressive dans cette période. La floraison et la fructification sont positivement corrélées avec la température maximale et négativement avec l'humidité relative de l'air. De même, la floraison est négativement corrélée avec la pluviométrie. Conclusions. Cette étude fournit des informations importantes pour une gestion durable de l'espèce dans les régions climatiques où elle est rencontrée.

Mots-clés : Floraison, fructification, gradient, pluviométrie, température, humidité relative.

Integrated Soil Fertility Management to Address Food Security and Enhance Forest Ecosystems Sustainability in "Trois Rivières" Forest Reserves (Benin, West Africa)

Lokossou R.S., Akouèhou G.S., Akponikpè I.P.B., Davakan R., Glèlè Kakaï R., Ganglo J.

Environmental Science and Engineering, (2019) 1193-1200 | **Impact Factor** $_{2020}$: 0.280
DOI: https://doi.org/10.1007/978-3-030-51210-1_189

The "Trois Rivières" natural forest reserves is one of the largest and strongly threatened rainforest ecosystems in Benin. That is mainly caused by extensive agriculture, which is mostly practised by smallholder farmers, aggravated by yields dropping linked to climate change. This research aims at analysing ecological practices that will enable smallholder farmers to increase yields on marginal lands and avoiding extensive agriculture towards forest ecosystems conservation. So, the conservation agriculture experimentation fields, using maize as basis crop, were installed, within agroforestry series on three sites chosen according to farmer's land use duration practices (Early fallow: after 6 years of cultivation, Under cultivation: after 3 years of cultivation and Late fallow: first year of cultivation after 6 years of fallow) according to a complete randomized block design split plot arrangement involving two factors: soil and water conservation (SWC) technologies three levels and type of fertilization five levels including improved fertilization called "microdose". Data were analysed by suitable tools and model in R software. Results revealed that the large ploughing perpendicular to the slope (GB) favours better the development of maize (Leaf Area Index) on early fallow (low fertile lands). Look at the grain yield, the fertilization type Recommended Dose (RD), consuming two more times fertilizer than Microdose manure (MDB), gives similar grain yields as MBD under GB. Thus, an application of microdoses combined manure (cow dung) under the GB might be the solution to increase the yield on low fertile or marginal land and allow settling farmers and limiting extensive agriculture in "Trois Rivières" natural reserve.

Keywords: Soil fertility management, Soil and water conservation, Microdose fertilization, "Trois rivières" natural forest reserve, Benin

Do functional identity and divergence promote aboveground carbon differently in tropical semi-arid forests and savannas?

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Ecosphere 12(6) 1-13 | **Impact Factor** $_{2020}$: 3.171
DOI: https://doi.org/10.1002/ecs2.3563

Various studies have shown that plant species richness can promote ecosystem functions such as biomass storage. However, it is less well known whether this is mostly driven by the dominance of a few species and their associated traits (functional identity), or by complementarity among species that highly vary in their traits (functional diversity). The relative contribution of functional diversity and functional identity on biomass and carbon storage may in part depend on the type of functional traits that are considered, and on ecosystem type. Here, we used forest inventory data from West African semi-arid environments, and functional traits (wood density and tree maximum height) to examine the effects of functional trait identity (FI or community weighted mean; CWM) and diversity (FD or single functional divergence; FDvar) on aboveground carbon (AGC) storage in both forests and savannas. We fitted simple linear and structural equation models to test the direct and indirect effects of functional traits on AGC, while accounting for potential effects of vegetation stand structure such as stand density and basal area. When evaluated independently, CWM of tree maximum height and FDvar of wood density correlated positively AGC, in both forests and savannas, whereas species richness was unrelated to AGC. However, structural equation models indicated different mechanisms by which these biodiversity components drove AGC in forests and savannas. In forests, species richness had an indirect, positive effect on AGC via basal area, but also an indirect, negative effect, through a reduction in CWM of maximum height. In savannas, species richness had a direct, negative effect on AGC, while both CWM of maximum height (through an increase in basal area) and FDvar of wood density had positive effects. Our study suggests that integrative models are crucial for understanding the effects of species richness, functional trait diversity, and identity on AGC across forests. Furthermore, our study shows that relationships between biodiversity and AGC differ among ecosystem types. In both forests and savannas, FI played an important role, as AGC was maximized in communities dominated by species a high maximum height. However, only in savannas a high FD additionally promoted AGC.

Keywords: community weighted mean, functional diversity, maximum plant height, semi-arid, tree biomass carbon.

Grazing exclosures increase soil organic carbon stock at a rate greater than "4 per 1000" per year across agricultural landscapes in Northern Ethiopia

Noulèkoun F., Birhane E., Kassa H., Berhe A., Gebremichael Z.M., Adem N.M., Seyoum Y., Mengistu T., Lemma B., Hagazi N., Abrha H., Rannestad M.M., Mensah S.

Science of the Total Environment, 782, 1-11 | **Impact Factor** $_{2020}$: 7.963
DOI: https://doi.org/10.1016/j.scitotenv.2021.146821

The establishment of grazing exclosures is widely practiced to restore degraded agricultural lands and forests. Here, we evaluated the potential of grazing exclosures to contribute to the "4 per 1000" initiative by analyzing the changes in soil organic carbon (SOC) stocks and sequestration (SCS) rates after their establishment on degraded communal grazing lands in Tigray region of Ethiopia. We selected grazing areas that were excluded from grazing for 5 to 24 years across the three agroecological zones of the region and used adjacent open grazing lands (OGLs) as control. Soil samples were collected from two depths (0–15 cm and 15–30 cm) and SOC and aboveground C stocks were quantified in both exclosures and OGLs. The mean SOC stock and SCS rate in exclosures (0–30 cm) were 31 Mg C ha−1 and 3 Mg C ha−1 year−1, which were respectively 166% and 12% higher than that in the OGLs, indicating a positive restoration effect of exclosures on SOC storage. With increasing exclosure age, SOC stock and SCS rate increased in the exclosures but decreased in the OGLs. Higher SOC stock and SCS rate were recorded in 0–15 cm than in 15–30 cm. The relative (i.e., to the SOC stock in OGLs) rates of increase in SOC stocks (70–189‰ year−1) were higher than the 4‰ year−1 and were initially high due to low initial SOC stock but declined over time after a maximum value of SOC stock is reached. Factors such as aboveground biomass, altitude, clay content and precipitation promoted SOC storage in exclosures. Our study highlights the high potential of exclosures for restoring SOC in the 0–30 cm soil depth at a rate greater than the 4‰ value. We argue that practices such as grazing exclosure can be promoted to achieve the climate change mitigation target of the "4‰" initiative.

Keywords: Organic carbon accumulation, Land degradation, Tree-mediated carbon sequestration, Sink saturation, Space-for-time approach, Tigray region

Medicinal use patterns of *Parkia biglobosa* (Jacq.) Benth. and *Vitellaria paradoxa* (Gaertn. F), two important traditional agroforestry species in Benin, West-Africa

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Advances in Traditional Medicine, (2021) 1-15 | **Impact Factor** 2020: 1.34
DOI: https://doi.org/10.1007/s13596-021-00583-6

In West Africa, African locust bean (*P. biglobosa* (Jacq.) Benth.) and Shea (*V. paradoxa* (Gaertn. F) are among the most important multipurpose plant species commonly found in traditional agroforestry systems. Most of research on these species are dominated by patterns and properties of their food uses, and additionally cosmetics for the shea. Yet, the species also have interesting medicinal properties that have been little explicitly explored. Using an ethnobotanical survey, we explored the patterns of diseases and other human disorders healed by the species, the diferent plants parts involved in diseases treatment, the recipes adapted for the treatment of the diseases and disorders and the other species involved in recipes composition in Northern Benin where they are widely distributed and used. Plants parts used by respondents were subjected to a Principal Component Analysis together the ethnic groups. Alpha diversity indices were used to compute disease diversity while the Intraspecifc Use Values index was applied to assess the frequency of utilization of each plant part. Results showed that 11 categories comprising 51 diseases and disorders were listed by respondents for the two species, the predominance of Gastro-intestinal diseases (RFC=31.10% for *P. biglobosa* and RFC=31.81% for *V. paradoxa*) and Infectious diseases (RFC=26.82% for *P. biglobosa* and RFC=27.27% for *V. paradoxa*). Most used plants parts were nuts (IVU=90.90%) and roots (IVU=90.90%) for *V. paradoxa* and roots (IVU=90.24%) and bark (IVU=70.73%) for *P. biglobosa*. The PCA analysis showed a strong variation in the used plants parts across the sociocultural groups.

Keywords: *P. biglobosa*, *V. paradoxa*, Natitingou, Medicinal uses, Benin

How far are mangrove ecosystems in Benin (West Africa) conserved by the Ramsar Convention?

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Land Use Policy, 108, 2-6 | **Impact Factor** 2020: 5.398
DOI: https://doi.org/10.1016/j.landusepol.2021.105583

Mangroves around the world provide humanity a variety of ecosystem services. However, rising populations coupled human activities jeopardize the sustainable management of these ecosystems. Climate change is also expected to have a severe impact on mangrove ecosystems, especially in Benin, West Africa. Since 2000, several initiatives for the conservation of mangroves have been established under the Ramsar Convention on Wetlands. Land use/land cover (LULC) changes were used at Ramsar Site 1017 in Benin for periods in 1995, 2005 and 2015 to assess the impact of the Ramsar Convention on mangrove ecosystem conservation. The observed changes during 1995–2005 and 2005–2015 were considered to predict LULC change towards 2070 using the Markov chain model. During 1995–2005, a total area of 3.43 ha of mangroves was degraded, while during the 2005–2015 period 2.65 ha were restored. Future scenarios predicted that the area of mangroves was expected to decrease by more than half between 1995 and 2070, assuming the dynamic of 1995–2005, and increase by 1.1% of the 2005 area by 2070 the dynamic of 2005–2015. Implementation of conservation policies, projects and awareness-raising activities could contribute to the effective restoration of the mangrove ecosystems.

Keywords: Mangroves Policy Land use/land cover Ramsar Site 1017 West Africa

Pattern of seedling emergence and early growth in *Avicennia germinans* and *Rhizophora racemosa* along an experimental salinity gradient

Sinsin C.B.L., Salako K.V., Fandohan A.B., Zanvo M.G.S., Kouassi K.E., Glèlè Kakaï R.

African Journal of Ecology, 59(4), 1013-1022 | **Impact Factor** $_{2020}$: 1.426
DOI: https://doi.org/10.1111/aje.12889

Salinity is a major driver of emergence and early growth of mangrove propagules. The magnitude of salinity effects may vary across mangrove ecotypes. Using a randomised complete block design in a semi-controlled experiment, this study assessed the effect of salinity (low: 3–5, moderate: 15–17 and high: 34–36 Practical Salinity Unit) on the emergence and early growth of *Rhizophora racemosa* (G.) Meyer and *Avicennia germinans* (L.) L., two common mangrove species in West Africa. Per cent emergence, total height and number of leaves were recorded daily for 30 days. Data were analysed using a three-parameter log-logistic distribution and linear mixed models. For both species, results showed significant effects of salinity on per cent emergence and growth variables. There was a negative correlation between salinity and per cent emergence of *A. germinans* and between salinity and height and number of leaves during the early growth phase of both species. However, the per cent emergence of *R. racemosa* was significantly higher for moderate salinity. To avoid the risk of dieback from osmotic shock after transplantation, we recommend the use of water of low or moderate salinity in nursery, depending on whether the soil salinity is low or high where the seedlings will be transplanted.

Keywords: black mangrove, emergence patterns, height, longitudinal data, number of leaves, red mangrove, salinity

Inference in skew generalized t-link models for clustered binary outcome via a parameter expanded EM algorithm

Tovissodé C.F., Diop A., Glèlè Kakaï R.

Plos one, 16(4) 1-31 | **Impact Factor** $_{2020}$: 3.24
DOI: https://doi.org/10.1371/journal. pone.0249604

Binary Generalized Linear Mixed Model (GLMM) is the most common method used by researchers to analyze clustered binary data in biological and social sciences. The traditional approach to GLMMs causes substantial bias in estimates due to steady shape of logistic and normal distribution assumptions thereby resulting into wrong and misleading decisions. This study brings forward an approach governed by skew generalized t distributions that belong to a class of potentially skewed and heavy tailed distributions. Interestingly, both the traditional logistic and probit mixed models, as well as other available methods can be utilized within the skew generalized t-link model (SGTLM) frame. We have taken advantage of the Expectation-Maximization algorithm accelerated via parameter-expansion for model fitting. We evaluated the performance of this approach to GLMMs through a simulation experiment by varying sample size and data distribution. Our findings indicated that the proposed methodology outperforms competing approaches in estimating population parameters and predicting random effects, when the traditional link and normality assumptions are violated. In addition, empirical standard errors and information criteria proved useful for detecting spurious skewness and avoiding complex models for probit data. An application respiratory infection data points out to the superiority of the SGTLM which turns to be the most adequate model. In future, studies should focus on integrating the demonstrated flexibility in other generalized linear mixed models to enhance robust modeling.

A Hybrid Modeling Technique of Epidemic Outbreaks Application to COVID-19 Dynamics in West Africa

Tovissodé C.F., Doumatè J.T., Glèlè Kakaï R.

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DOI: https://doi.org/10.3390/biology10050365

The widely used logistic model for epidemic case reporting data may be either restrictive or unrealistic in presence of containment measures when implemented after an epidemic outbreak. For flexibility in epidemic case reporting data modeling, we combined an exponential growth curve for the early epidemic phase a flexible growth curve to account for the potential change in growth pattern after implementation of containment measures. We also fitted logistic regression models to recoveries and deaths from the confirmed positive cases. In addition, the growth curves were integrated into a SIQR (Susceptible, Infective, Quarantined, Recovered) model framework to provide an overview on the modeled epidemic wave. We focused on the estimation of: (1) the delay between the appearance of the first infectious case in the population and the outbreak ("epidemic latency period"); (2) the duration of the exponential growth phase; (3) the basic and the time-varying reproduction numbers; and (4) the peaks (time and size) in confirmed positive cases, active cases and new infections. The application of this approach to COVID-19 data from West Africa allowed discussion on the effectiveness of some containment measures implemented across the region.

Keywords: growth model, epidemic latency period, reproduction number, West Africa

Rhizobacterial inoculation in combination wxith mineral fertilizer improves maize growth and yield in poor ferruginous soil in central Benin

Amogou O., Noumavo A.P., Agbodjato N.A., Sina H., Dagbénonbakin G., Adoko M.Y., Salako K.V., Glèlè Kakaï R., Adjanohoun A., Baba-Moussa L.

BioTechnologia. Journal of Biotechnology Computational Biology and Bionanotechnology, 102(2), 141-155
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The use of biotechnological approaches to increase soil fertility and productivity allows to obtain sustainable agriculture lesser use of chemical fertilizers. The present study aimed to determine whether the inoculation of *Bacillus panthothenicus, Bacillus thuringiensis, Pseudomonas putida*, *Pseudomonas syringae,* or *Serratia marcescens* combined reduced doses of NPK (nitrogen, phosphorus, potassium) fertilizer can improve the growth and yield of maize on poor ferruginous soils under field conditions in central Benin. For this purpose, maize seeds of the EVDT 97 STR C1 variety were inoculated 10 ml suspension of five plant growth-promoting rhizobacteria (PGPR) strains, and the plots were fertilized at seeding the recommended doses (0, 25, 50, 100%) of 200 kg/ha of NPK and 100 kg of urea for corn cultivation. The study was conducted in a completely randomized design 3 replicates. The results showed that except *for P. syringae*, which induced the highest fresh aerial biomass (94.51%) and dry aerial biomass (63.63%), all other parameters were positively improved inoculation associated reduced doses of NPK + urea. The best height, leaf area, fresh underground biomass, and grain yield were recorded in response to the application of *P. syringae* + 50% NPK + urea, an increase of 26.82, 32.23, 107.57, and 30.64%, respectively, compared to those of the control. The inoculation of seeds *P. syringae* + 50% NPK + urea can be considered to be an environmentally sustainable strategy for maize cultivation.

Keywords: PGPR, biofertilizer, poor ferruginous soil, Zea mays L., Benin

Promotion of beekeeping: Insights from an empirical analysis of three honey value chains in Benin

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DOI: https://10.1111/1477-8947.12238

Beekeeping is increasingly promoted in developing countries as a promising option for income diversification in rural areas while contributing to poverty alleviation. Unfortunately, the development of the value chains of its most known and marketed product (honey) is still in its beginning stages. Little is known about the honey value chain environment and entry points for its development. Through interviews 406 informants, this study investigated three honey value chains – "honey harvested in wild," "honey from traditional beekeeping" and "honey from semi modern beekeeping." Data was collected on their operation, profitability, and long-term perspectives. The following agents

were involved in the value chains: input suppliers, honey producers, middlemen, transporters, and consumers. Farmer's associations, government, non-governmental organizations, quality control organizations, and financial organizations were also involved in the operation of the value chain of honey from semi-modern beekeeping. In the case of the value chains of honey harvested in the wild and honey from traditional beekeeping, only a government department and financial organizations were involved in its operation. Networks were the main coordination mechanism in the value chain of honey from semi-modern beekeeping. There was a low representativeness of market coordination in the three value chains. The value chain of honey from semi-modern beekeeping had the high value-added. All of the value chains were financially profitable, but various weaknesses prevented the efficiency of the value chains. Relevant policy options are discussed to address these issues.

Keywords: Benin, governance, honey production, institutional environment, performance, Value chains

Potential climate change induced modifications in mangrove ecosystems: a case study in Benin, West Africa

Sinsin C.B.L., Salako K.V., Fandohan A.B., Kouassi K.E., Sinsin B.A., Glèlè Kakaï R.

Environment, Development and Sustainability, (2021) 1-17 | **Impact Factor** $_{2020}$: 3.219
DOI : https://doi.org/10.1007/s10668-021-01639-y

Mangroves are one of the most threatened ecosystems globally. Likewise, they benefit many restoration efforts. However, these efforts have often disregarded potential effects of climate change on selected species and foreseen changes in physico-chemical conditions of mangrove ecosystems. This study aimed to model current and future climatic and physico-chemical conditions in occupied mangroves' niche, in order to derive implications for successful long-term restorations. Presence records of mangroves' indicator species and corresponding physico-chemical variables were collected. Bioclimatic data were obtained from Africlim. Kruskal–Wallis and Nemenyi pairwise tests for multiple comparisons were used to test the among sites (spatial) variations of climatic and physico-chemical variables within mangroves' niche. Multiple linear regression (MLR) and artificial neural network (ANN) were used to build predictive models of salinity, dissolved oxygen, and conductivity; using most meaningful climatic variables to tropical mangroves—potential evapotranspiration, temperature seasonality, mean temperature of the warmest quarter, moister index of the moist quarter, and moister index of the driest quarter as predictors. Results showed that there are strong spatial variations of climatic and physico-chemical variables within mangroves' niche. ANN outperformed MLR and was then used to predict trends in salinity, dissolved oxygen, and conductivity by year 2055. Based on foreseen trend in bioclimatic variables, conductivity, salinity, and dissolved oxygen will experiment significant changes under Representative Concentration Pathways 4.5 and 8.5, most severe changes in case the later scenario occurs. Foreseen salinization of sites may be at the advantage of *Avicennia germinans* but to the prejudice of Rhizophora spp.

Keywords: *Avicennia germinans*, Rhizophora spp, Restoration, Representative concentration pathways, Physico-chemical, Predictive models

A general strategy for setting up supervised methods of multiblock data analysis

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A general strategy for setting up supervised methods of multiblock data analysis is outlined. This yields a unified framework where some already known methods are retreived and novel extensions are introduced. All the methods of analysis are based on the determination of latent variables associated the various blocks of variables. They are derived from clear optimization criterion whose aim is to maximize either the sum of the covariances or the sum of squared covariances between the latent variable associated the response variables and the block latent variables associated the various explanatory datasets. New indices are proposed to help better interpreting the outcomes of the analyses. The methods are illustrated and compared based on simulated and real datasets.

Keywords: Multiblock data analysis, Redundancy analysis, PLS regression, Supervised methods, Multicolinearity

Abundance and effects of climate change on geographical distribution of *Mondia whitei* (Hook.f.) Skeels (Apocynaceae) in the Dahomey Gap (West Africa)

Vihotogbé R., Idohou R., Vianou A., Spies P., Salako K.V., Assogbadjo A., Glèlè Kakaï R.

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DOI: https://10.1111/aje.12914

African healthcare system depends upon indigenous medicinal plants, harvested wild and traded for significant income generation. *Mondia whitei*, one of these plants, is threatened by over-exploitation, climate change and unsustainable land use management. Detailed knowledge is lacking regarding the species' conservation—driving forces and preservation of its ecological niche within fragile ecological regions. This study assessed the influence of the land use types on the abundance of *M. whitei* and the spatio-temporal evolution of its ecological niche in the Dahomey Gap. The abundance of the species was evaluated in different land use systems. Available bioclimatic and soil layers were used for the distribution modelling. Results showed that *M. whitei* was mainly found in three land use systems: cropland, fallow and forests. Density of adults averaged 281.5 ± 99.1, 323.2 ± 93.9 and 305.9 ± 154 individuals/ha in fallow, forest and cropland, respectively. For juveniles, density was on average of 222.2 ± 205.7 individuals/ha in cropland vs 59.3 ± 71.8 and 57.4 ± 94.1 individuals/ha in forest and fallow, respectively. The majority of the species distribution will possibly remain stable some expansion under future climates. Persistence of the species' niche in the Dahomey Gap under climate change indicates its potential as a contributor to future livelihood improvement, via local health care and the strengthening of local economy.

Keywords: Dahomey Gap, land use types, medicinal plants, *Mondia whitei*

Effects of the oil-find on land management in the Sekondi-Takoradi Metropolis, Western Coast of Ghana

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Journal of Land Use Science, 16(4), 398-412 | **Impact Factor** $_{2020}$: 2.885
DOI: https://doi.org/10.1080/1747423X.2021.1991018

The recent oil-find at the 'Jubilee Fields' has impacted every sector of Ghanaian life. There is a need to understand these changes, to better manage their effects. This study investigated the dynamics surrounding land management in Sekondi-Takoradi following the oil find. Data were collected from the city in 2018 using qualitative approaches like direct observations, in-depth interviews and informal conversation. All in all, 65 informants were consulted using purposive and snowball sampling techniques. This data was analysed by listening, transcribing, coding interviews, identifying relevant information and matching results the objectives of this study. Our findings indicate a growing demand for land which has resulted in an increase in land conflicts in the metropolis. There is, therefore, the need to revise future land use patterns and land tenure forms as well as strengthening existing institutions and legislation, among others, in a bid to achieve a sustainable city.

Keywords: Jubilee fields, land conflicts, immigration, oil city, Ghana

Soil seed bank characteristics along a gradient of past human disturbances in a tropical semi-deciduous forest: Insights for forest management

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Forest Ecology and Management, 503, 1-12 | **Impact Factor** $_{2020}$: 3.558
DOI: https://doi.org/10.1016/j.foreco.2021.119744

The soil seed bank (SSB) in forests is a key indicator of their resilience after disturbances. Despite the growing interest in describing patterns of SSB and understanding potential processes underpinning those patterns, we still know little about SSB patterns and drivers in semi-deciduous tropical forests. Using the regeneration emergence method, we assessed the patterns of SSB (i) across four vegetation types variable intensity of past human disturbances: typical dense forest - degraded dense forest - young preforest fallow - old preforest fallow, and (ii) in relationships to soil depth (0–5 cm, 5–10 cm, 10–15 cm, 15–20 cm) in a protected tropical semi-deciduous dense forest in Benin, West-Africa. The standing vegetation (adults and regeneration) data and soil samples were collected using a systematic sampling of 60 plots of 10 m × 10 m in the four vegetation types. Herbaceous plants dominated (67% □ 78%) the SSB. From the SSB, five tree species emerged: *Ceiba pentandra* (L.) Gaertn., *Dialium guineense* Willd., Ficus sur Forssk., *Leucaena leucocephala* (Lam.) De Wit, and *Lonchocarpus sericeus* (Poir.) Kunth. Regarding tree species, the total densities of germinated seeds (seeds.m2) were higher in typical dense forest (28.00 ± 7.22) and young preforest fallow (16.67 ± 7.07) than in old preforest fallow (10.00 ± 6.75) and degraded dense forest (8.89 ± 3.81). When only tree species were considered, the SSB was more diverse and denser in typical dense forest than in other vegetation types suggesting negative effect of past human disturbances on SSB. The similarity of the species composition between the SSB and the surrounding vegetation was low (Jaccard's similarity index ranged from 0 to 17.64%, indicating that the majority of tree species in the surrounding vegetation were absent in the SSB. This study highlighted a need of planting effort of native tree species to restore degraded areas.

Keywords: Soil seed bank Floristic similarity Regeneration Density Diversity Western Africa

Efficacy of Native Strains of Arbuscular Mycorrhizal Fungi on Maize Productivity on Ferralitic Soil in Benin

Aguégué M.R., Adjovi N.R.A., Agbodjato N.A., Noumavo P.A., Assogba S., Salami H., Salako K.V., Ramon R., Baba-Moussa F., Adjanohoun A., Glèlè Kakaï R., Baba-Moussa L.

National Academy of Agricultural Sciences, (2021) 1-15 | **Impact Factor** $_{2020}$: 0.99
DOI : https://doi.org/10.1007/s40003-021-00602-7

In a context of sustainable agriculture, the use of arbuscular mycorrhizal fungi (AMF) represents a potential tool for environmentally friendly agricultural management in the face of the challenges of climate change and the reduction in the costs and disadvantages of mineral fertilization. This study therefore aims to evaluate the performance of five indigenous strains of AMF (*Glomus caledonius, Rhizophagus intraradices, Funneliformis geosporum, Acaulospora capsicula, Acaulospora dilatata* and *Diversispora globifera*) on maize productivity. The experimental design was a split-split plot three replicates chemical fertilizer and type of mycorrhizal fungus as factors. The different parameters of growth, yield and mycorrhization were evaluated. The results obtained showed that inoculation of corn the native strains of AMF had a significant effect (P\0.01) on corn growth and yield. Of all the native AMF strains, co-inoculation of *G. caledonius* + *R. intraradices* + *F. geosporum* in combination 50% NPK + Urea of the recommended dose induced the best growth and an increase in maize grain yield of 62.5% compared to uninoculated plants. In addition, the root colonization rate of maize plants was 46% for a quantity of 2 and 3 spores/g of soil. The study shows the possibility of valorizing Benin's indigenous AMF as bio-fertilizers while reducing by 50% the use of mineral fertilizers for maize cultivation.

Keywords: Mycorrhization parameters, Sustainable agriculture, Fertilizer rates, Ecological environment, Zea mays L. Symbiosis, Maize biomass

Organic Fertilizer Based on *Rhizophagus intraradices*: Valorization in a Farming Environment for Maize in the South, Center and North of Benin

Aguégué R.M., Assogba S.A., Salami H.A.A., Koda A.D., Agbodjato N.A., Amogou O., Sina H., Salako K.V., Adjovi N.R.A., Dagbénonbakin G., Glèlè Kakaï R., Adjanohoun A., Baba-Moussa L.

Frontiers in Sustainable Food Systems, 5, 1-10 | **Impact Factor** 2020: 3.95
DOI : https://10.3389/fsufs.2021.605610

Maize plays an important role in agricultural production systems in all agro-ecological zones of Benin. Despite its importance, its production faces many constraints including soil fertility. One of the ecological technologies aimed at improving agricultural production is the use of soil microorganisms including arbuscular mycorrhizal fungi (AMF). This study aims to evaluate the effectiveness of *Rhizophagus intraradices*, an indigenous strain, on maize productivity in farmers' areas in the Research and Development (RD) sites of the North (Ouénou), Center (Miniffi), and South (Zouzouvou). Three maize producers were selected at each RD site, for nine maize producers. The experimental design was a randomized complete block of three treatments three replications. The different treatments were (i) Control–farmer's practice, (ii) *R. intraradices* + 50% of the recommended dose of NPK and urea, and (iii) 100% of the recommended dose of NPK and urea. Soil samples from the different RD sites were taken at a depth of 0–20 cm before sowing for chemical analysis. The different growth parameters (height, crown diameter, and leaf area), grain yield, and endomycorrhizal infection of maize plants were evaluated. The results showed that the soils were moderately acidic (5.5 ≤ pH waters ≤ 6.8) and low in organic matter (0.95 ≤ 33 OM ≤ 1.17) regardless of the study area. The greater maize grain yield was recorded application of 100% of the recommended dose of NPK and urea, and *R. intraradices* + 50% of the recommended dose of NPK and urea. In the RD sites at the South, Center, and North recorded *R. intraradices* + 50% of recommended dose of NPK and urea, the grain yields of 1.9, 3.4, and 1.74 t/ha an increase of 28, 38.21, and 13.21%, respectively, compared farmer's practice. Mycorrhization frequencies in plants treated Ri½ N15P15K15 vary between 37.44 and 51.67% in the three zones. The results of the current study have proven the potential use of *R. intraradices* in sustainable intensification of maize production in Benin.

Keywords: *Rhizophagus intraradices*, farming environment, ecological systems, yield, maize, Benin

On opportunities and challenges to conserve the African baobab under present and future climates in Benin (West Africa)

Assogba D., Idohou R., Chirwa P., Assogbadjo A.E.

Journal of Arid Environments, 198, 1-7 | **Impact Factor** 2020: 2.22
DOI: https://doi.org/10.1016/j.jaridenv.2021.104692

African baobab (Adansonia digitata) is an agroforestry species used by local people for many purposes such as food, medicine, craft, etc. It is uncertain how climate change will impact the suitability of the habitat for the species in Benin. This study aimed to assess the present-day distribution and forecast the probable impact of future climate and provide sustainable management strategies for the species in Benin. Records of the species were gathered both from fieldwork and through available databases. Environmental data comprised both climatic and soil layers. We transferred the present-day models into future climates under two scenarios (RCP 4.5 and RCP 8.5) using Maxent software. Our results showed high suitability of the Benin territory for African baobab in the present. In addition, high stability of suitable areas was observed for the species in the future across Benin. However, some protected areas are predicted not to effectively conserve the species in the future. We believe that both ex-situ and in-situ conservation measures will help to maintain the African baobab population in the future.

Keywords: Baobab, Habitat suitability, Modeling, Conservation

Spatial distribution patterns of *Afzelia africana* (Fabaceae – Detarioideae) in a tropical savanna of Benin: implications for management

Atanasso J.A., Salako K.V., Mensah S., Tohoun R.J., Djossa B.A., Glèlè Kakaï R., Assogbadjo A.E.

Plant Ecology and Evolution, 154 (3): 362–375 | **Impact Factor** $_{2020}$: 1.366
DOI: https://doi.org/10.5091/plecevo.2021.1713

Background and aims – Understanding the spatial patterns and associations of tree species their conspecific and heterospecific neighbours is critical for sustainable management of their stands. This study assessed the intra- and interspecific spatial structure of six life stages in *Afzelia africana*, a keystone multipurpose and endangered tree species in a tropical savanna of Benin. *Material and methods* – Three plots of 4 ha each were demarcated on three sites along a conservation gradient (hunting zone – core conservation zone). Individuals of *A. africana* (irrespective of their diameter at breast height) and heterospecific trees (dbh ≥ 5 cm) were mapped. Tree spatial patterns and associations were determined using univariate and bivariate pair correlation functions. The distance to the nearest neighbour was further used to assess tree-to-tree distance. *Key results* – We found variable spatial patterns across sites. In the core zone where wildlife density is high, most life stages had a random distribution. In contrast, in the hunting zone where wildlife density is low, the species spatial distribution changed from a predominantly aggregative pattern during early stages to a less aggregative or random spatial pattern for very large adults. Most pairs of life stages showed neutral associations, except for small and large adults, which had positive association between themselves on two sites. We also found that *A. africana* tree spatial distribution was unrelated to heterospecific trees. *Conclusion* – We suggest that bush fire, seed dispersion, predation, and local environment would have contributed to the observed patterns.

Keywords: Pair correlation function, plant coexistence, plant-plant interactions, point pattern process, silviculture, tree-to-tree distance.

Current state of nutrition in West Africa and projections to 2030

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Global Food Security, 32, 1-8 | **Impact Factor** $_{2020}$: 7.772
DOI: https://doi.org/10.1016/j.gfs.2021.100602

The rapid growth of the human population in West Africa makes malnutrition a pressing issue. This paper highlights the predicted nutritional issues in West Africa by 2030. Data were extracted from the FAOSTAT 2019 database and national nutritional reports. Countries were clustered based on the prevalence of different forms of malnutrition. Trends in the different forms of malnutrition were used to estimate nutritional issues in West Africa by 2030 for each country. Four clusters of countries were identified based on malnutrition indicators. These clusters are different in terms of the prevalence of childhood overweight (cluster 1), stunting (cluster 2), anemia (cluster 3) and wasting (cluster 4). Overall, most countries are not on track in meeting global targets of addressing malnutrition by 2030, especially for anemia.

Keywords: Stunting, Wasting Anemia, Overweight, Nutritional trends

Overview of the use of pre-harvest equipment and typology of Tractor users in Benin republic

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Annales des sciences agronomiques, 24(2), 109-119
DOI: https://www.researchgate.net/publication/355189572

Agricultural mechanization level and tractor user's groups vary from one country to another. This study aims to assess the status of the use of pre-harvest equipment and tractor users in Benin Republic. A total of 203 respondents were surveyed over the country using a questionnaire. The sample size was determined using the normal approximation of binominal distribution sampling method. The data were subjected to a Hierarchical Classification on Main Components carried out through a Factorial Analysis of Mixed Data followed by an Ascending Hierarchical Classification. Fourteen (14) brands of tractors were identified powers ranged from 30 to 120 horsepowers. The brand Mahindra (42.36 %) was most represented. Tillage equipment (Disc plough (100 %), Disc harrow (6.90 %)) were most used than other (Seeder (1.48 %), Harvester (0.49 %)). Four groups of tractor users were identified. Group 1 (64.52%) of tractor users, consisted mainly of independent contractors no secondary activity, agronomists, or tractor drivers and to a lesser extent independent contractor farming more than 90 ha/year. Group 2 (15.05 %) of users was made up of independent entrepreneurs who were farmers, fishermen, traders or part-time trainers and sowed less than 90 ha per year. The third group represented 15.59 % and was composed of entrepreneurs who were members of the cooperative. Group G4 (4.84 %) consisted of entrepreneurs who were members of a government agency. The results show the presence of most conventional tillage equipment and call for innovation of new equipment for sustainable agriculture. The variability of groups of machinery users could help decision makers to take action and support each group according to their need.

Keywords: Agricultural equipment, farmer, hierarchical clustering, tractor, mechanization.

Structure et modèle de gouvernance de la Réserve Transfrontalière de Biosphère W du Bénin

El-hadj Issa A., Gbemavo D.S.J.C., Gbedomon R.C., Salako K.V., Mensah G.A., Sinsin B.A.

Bulletin de la Recherche Agronomique du Bénin, 31(01), 46-64
DOI: https://www.researchgate.net/publication/357173506

National parks are of great interest for the biodiversity conservation and ecosystem services delivery. However, their effectiveness in achieving the objectives that motivated their establishment depends on the performance of the governance model. Using the case study of the Transboundary Biosphere Reserve of W, Benin (TBRW/B) for the period 2000-2017, the study explored the structure and the governance of this Biosphere Reserve, the ultimate aim to identify success factors to inform decision makers. In total, 121riparians (15 women et 106 men) randomly selected local residents were interviewed. The data analysis approach included stakeholders and network analyses, an assessment of power and dominance of actors and the decision-making process. The cumulative distribution of the links and the absolute value distribution of the links were established in order to assess both the complexity of the networks and the degree of distribution of the actors in the networks. Findings indicated a complex structure of governance abundant nodes (about 23 actors) and important connections (2 to 40 links), though the structure was egocentric mainly from the board of the TBRW/B (central government). Therefore, the improvement of the effectiveness of the TBRW/B's inclusive governance model is necessary, by valuing theoretical connections across the network and establishing a framework for dialogue that values the contribution of all stakeholders and elicits more engagement on their part as partners.

Keywords: Governance, Biological diversity, network, protected area, Benin.

Effects of seed provenance, pre-treatment and mass on germinability and seedling growth of *Balanites aegyptiaca* (L.) Delile and *Ricinodendron heudelotii* (Bail.) Pierre in Benin (West Africa)

Hounsou-Dindin G., Idohou R., Donou Hounsode M.T., Adomou A.C., Assogbadjo A.E., Glèlè Kakaï R.

Heliyon, 7(12), 1-10
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Balanites aegyptiaca (L.) Delile and *Ricinodendron heudelotii* (Bail.) Pierre are socioeconomically important species in sub-Saharan Africa. This study was conducted to assess the seed germinability and seedling growth of those species based on several treatments and to define proper conservation and domestication strategies in Benin. The seeds were randomly collected in their natural habitats. The experiment was conducted using a split-split plot design and the data was analyzed using the generalized linear mixed and survival models. The heaviest seeds (*B. aegyptiaca* seed mass 3 g and *R. heudelotii* 1.50 g) provided the highest germination rates (73.60 - 5.19% and 62.50 _ 5.71%, respectively) when seeds were scarified a hammer. For *B. aegyptiaca* seedlings, the seeds from the phytodistrict of North Borgou scarified a hammer and the heaviest seeds showed the highest total height (36.43 -1.03 cm), basal diameter (2.84 -0.03 mm), the greatest number of leaves (32), and ramifications. The heaviest seeds of *R. heudelotii* had also the highest value for total height at the day-28 after sowing (26.73 - 13.56 cm) until the day-105 (151.97-6.37 cm). The heaviest seeds of *R. heudelotii* from the phytodistrict of Pobe showed the highest basal diameter (12.53 -1.47 mm) and the greatest number of leaves (14), almost no ramification during the trial period. These findings constitute a step forward in upscaling the reproduction of these species for better contribution to economies while serving in restoration plans.

Keywords: Agroforestry species, Domestication, Germination rate, Phytodistrict, Scarification, Wild oil species

Effet des traitements et du substrat sur la germination et la croissance de sept espèces ligneuses d'importance socio-économique et médicinale au Bénin

Lègba S.I., Assèdé E.S.P., Salako K.V., Sacla Aide E., Adomou C.A., Mensah G.A.

Bulletin de la Recherche Agronomique du Bénin, 31(02), 60-74
DOI : https://www.researchgate.net/publication/357935203

Adansonia digitata L., *Afzelia africana* Sm., *Dialium guineense* Willd., *Diospyros mespiliformis* Hochst. ex A. De., *Khaya senegalensis* (Desr.) A. Juss., *Kigelia africana* (Lam.) Benth., Tamarindus indica L., are seven tree species indigenous to Benin of socio-economic and medicinal importance, but vulnerable and having recalcitrant seeds. The treatments and substrates used to seed dormancy break to increase their germination rate and stimulate germination performance and seedling growth are species dependent. Thus in addition to the control (T0), the germination tests integumentary scarification boiling water (T1), cold water from the seeds for 24 hours (T2), concentrated sulfuric acid for 60 min (T3) or for 30 min (T4), alcohol for 30 min (T5) were applied to the seeds of the seven species on three substrates (100% humus, 100% potting soil and 50% humus + 50% potting soil). Testing over 40 days identified the best methods of propagation. The results showed that seeds that had undergone T1 treatments had the best germination rates (70-100%). Control seeds of A. digitate (70-90%), K. senegalensis (90-100%) and T. indica (90-100%) had high rates on all three substrates. The potting soil substrate and the potting soil-humus substrate the T4 treatment favored the growth of seedlings which was faster for *D. mespiliformis* on the humus substrate. The control seeds *A. digitata, A. africana, D. mespiliformis, K. senegalensis and T. indica* experienced progressive dynamics on the three substrates. However, the most accelerated seedling growth was recorded on the potting medium for *A. africana, K. africana and T. indica*. In short, the T1 treatment is favorable for better germination of the seeds of the species studied. In addition, the potting soil and the potting soil ensure the rapid growth of the seedlings.

Keywords: Tree at merchant value, germination capacity, vegetative development, seeds, conservation.

Spatial patterns of light-demanding tree species in the Yangambi rainforest (Democratic Republic of Congo)

Luambua N.K., Hubau W., Salako K.V., Amani C., Bonyoma B., Musepena D., Rousseau M., Bourland N., Nshimba H.S.M, Ewango C., Beeckman H., Hardy O.J.

Ecology and Evolution, 11(24), 18691-18707 | **Impact Factor** $_{2020}$: 2.91
DOI: https://10.1002/ece3.8443

Most Central African rainforests are characterized by a remarkable abundance of light-demanding canopy species: long-lived pioneers (LLP) and non-pioneer light demanders (NPLD). A popular explanation is that these forests are still recovering from intense slash-and-burn farming activities, which abruptly ended in the 19th century. This "human disturbance" hypothesis has never been tested against spatial distribution patterns of these light demanders. Here, we focus on the 28 most abundant LLP and NPLD from 250 one-ha plots distributed along eight parallel transects (~50 km) in the Yangambi forest. Four species of short-lived pioneers (SLP) and a single abundant shade-tolerant species (*Gilbertiodendron dewevrei*) were used as reference because they are known to be strongly aggregated in recently disturbed patches (SLP) or along watercourses (*G. dewevrei*). Results show that SLP species are strongly aggregated clear spatial autocorrelation of their diameter. This confirms that they colonized the patch following a one-time disturbance event. In contrast, LLP and NPLD species have random or weakly aggregated distribution, mostly Wspatial autocorrelation of their diameter. This does not unambiguously confirm the "human disturbance" hypothesis. Alternatively, their abundance might be explained by their deciduousness, which gave them a competitive advantage during long-term drying of the late Holocene. Additionally, a canonical correspondence analysis showed that the observed LLP and NPLD distributions are not explained by environmental variables, strongly contrasting the results for the reference species *G. dewevrei*, which is clearly aggregated along watercourses. We conclude that the abundance of LLP and NPLD species in Yangambi cannot be unambiguously attributed to past human disturbances or environmental variables. An alternative explanation is that present-day forest composition is a result of adaptation to late-Holocene drying. However, results are inconclusive and additional data are needed to confirm this alternative hypothesis.

Keywords: African forest ecology, forest composition, light-demanding species, spatial analysis, Yangambi biosphere reserve

Land use impacts on *Boswellia dalzielii* Hutch., an African frankincense tree in Burkina Faso

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Boswellia dalzielii Hutch., an African frankincense tree, is a socio-economically important aromatic and medicinal tree. It is currently threatened by uncontrolled exploitation, and therefore requires action to ensure its sustainable management. This study assessed the population structure and regeneration of its natural stands across three land use types in Burkina Faso: woodlands, fallows and farmlands. Sixty, fifty and fifty 50 m × 20 m plots were established respectively in woodlands, fallows, and farmlands. All the plots were surveyed for adult tree (dbh ≥ 5 cm) density, dbh, total height and health conditions. Data on regeneration density (dbh < 5 cm), source (generative, stem sprouts, suckers), total height and collar diameter were also collected. The results show similar total tree heights (7.0 m-9.0 m) but significantly ($p < 0.05$) smaller tree dbh in woodlands (mean ± SD: 20.5 ± 0.49 cm) and fallows (29.3 ± 0.64 cm) than in farmlands (32.8 ± 0.15 cm). Adult tree density (trees/ha) was 1.3 and 2.7 times higher in woodlands (82.37 ± 6.57) than in fallows (62.00 ± 3.98) and farmlands (30.02 ± 1.63), spectively. The density of regeneration in woodlands was28 and 6 times higher than in fallows and farmlands, respectively. The majority (> 50%) of regenerating plants were suckers and no seedling regeneration was found in farmlands. The distribution of trees in diameter classes was inverted J-shaped in woodlands, bellshaped in farmlands and positive asymmetric in fallows, indicating recruitment bottlenecks. We found that 80.18% of individuals encountered were unhealthy. Intensive debarking and cutting were the main threats to the species and no conservation strategy was in place in the study region. We suggest measures to reduce intensive debarking and cutting, which should contribute to better management of the species.

Keywords: anthropogenic pressure, *Boswellia dalzielii*, conservation, population structure, Burkina Faso.

Risques agro-météorologiques et production du riz pluvial (Oryza spp.) au Bénin

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Irregular and reduced rainfall are major concerns for rainfed rice producers. The objective of this study was to analyze the yearly variability and trends of the onset and the end of rains as well as of total rainfall over a period of 46 years in Glazoue, Malanville and Tanguiéta (Benin) in order to better determine the appropriate dates for rainfed rice sowing. For this purpose, daily rainfall data (1970-2016) were collected from three weather stations located in these localities from the Benin National Weather Agency. Descriptive statistics were used to compare rainfall variability. Trends were assessed by Mann-Kendall test and Sen's Slope. The probabilities of occurrence of a dry period were calculated using the Markov chain of order 1. Unlike the end of the rains, where little variability was observed, a significant variability in the onset of rains late (4%) and early (17%) trends was found. Depending on the rice variety, the period from 9 May to 3 July is appropriate for rainfed rice sowing in Tanguiéta. In the case of, Glazoue and Malanville, no appropriate date for rainfed rice sowing was observed, due to the very high probabilities (0.7 to 1) of dry period (> 5 days) at flowering stage, which compromising its productivity. These results should encourage rice producers to grow varieties short < 100 days maturing dates and can guide them in the choice of suitable planting dates and suitable varieties of rainfed rice.

Keywords: Rainfed rice, climatic trends, Markov chain, dry period, cultural calendar