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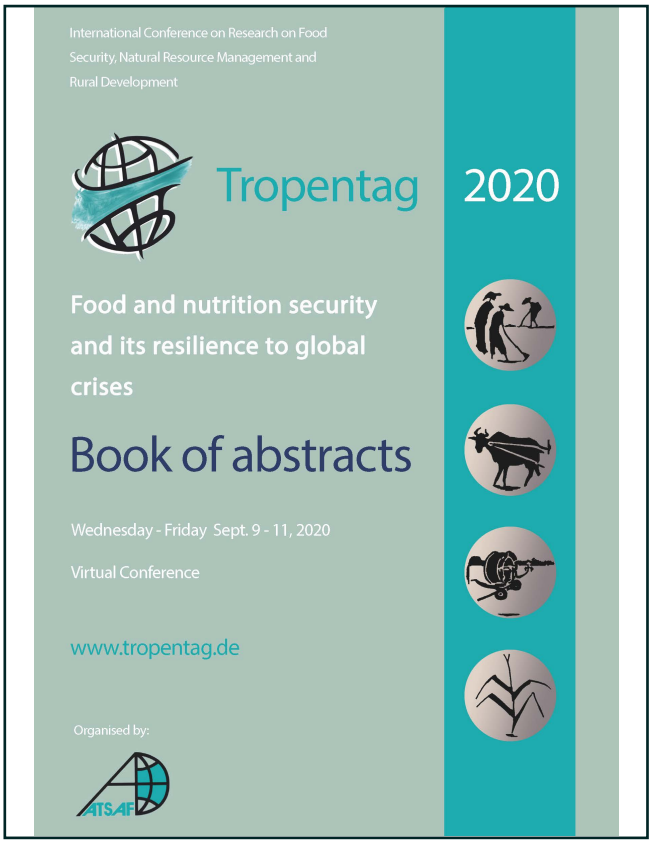

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Modelling Land Suitability for Expansion of Irrigated Rice and Dissemination of Alternate Wetting and Drying Water Management in Burkina Faso

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Spatially explicit assessment of land suitability can guide the identification of cropland with the highest potential for irrigated rice development, but for many regions in sub-Saharan Africa, the knowledge is very limited. Besides, reducing water input while maintaining rice yield is important for sustainable rice production in SSA. The objectives of this study were to produce a nation-wide prediction of irrigated rice area and estimate the climatic suitability of the alternative wetting and drying (AWD) technique of irrigation. We applied three environmental niche modelling (ENM) approaches that use machine learning algorithms along with the current distribution of irrigated rice locations in Burkina Faso to determine the extent of the potentially irrigated rice area. We used a simple water balance model to estimate the climatic suitability for AWD for the two main growing seasons: February – June and July – November. The evaluation metrics of the ENMs such as Area Under the Curves (AUC) and Percentage Correctly Classified (PCC) were higher than 90 % and 80 % for both training and testing, respectively. Exchangeable sodium percentage, distance to stream networks, exchangeable potassium, precipitation of the warmest quarter, annual mean temperature, soil depth to bedrock, topographical wetness index, actual evapotranspiration, soil organic carbon stock, and total phosphorous were the top 10 predictors determining a land suitability for irrigated rice development. The modelling predicted that 3 million ha of land are potentially suitable for irrigated rice cultivation in Burkina Faso. Most of these suitable lands are located within the sub-Sahelian and north-Sudanese climatic zones while the Sahelian climatic zone only showed marginal suitability for irrigated rice. About 97 % of the suitable lands for irrigated rice cultivation were found to be appropriate for AWD in the first growing season against 57 % in the second growing season. The results of this study can guide investments in irrigated rice development and large-scale dissemination of AWD in SSA.

Keywords: Alternate wetting and drying, climate change, ecological niche modelling, land suitability, rice

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Potentials and Risks of Alternate Wetting and Drying in Rice Production of the Dry Savannah Zone of West Africa

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Irrigated rice farming plays a vital role in global food security but also requires more water than any other staple crop. Meeting the high demand for rice to feed the growing population under increasing water scarcity is one of the major challenges of the twenty-first century. Alternate wetting and drying (AWD) is one of the most widely advocated water-saving irrigation technologies. The technology was introduced only recently in the dry Savannah zone of West Africa, where it is still largely unknown by farmers. We assessed the effect of AWD on grain yield and irrigation water productivity against the backdrop of possible N losses. Participatory on-farm trials compared AWD to farmers' irrigation practice in four irrigation schemes of Burkina Faso during both the dry and the wet seasons of 2018 and 2019. AWD was compared to farmer' irrigation practice (FP) in 156 pairwise comparisons of AWD and FP plots. In addition, soil nitrate-N dynamics in relation to soil water content was assessed in dry season 2019. Compared to farmers' practice (FP), irrigation water input with AWD technology was reduced by 32 % in the dry and by 25 % in the wet season. With no significant effects on grain yields (mean of 4.9 Mg ha^{-1}) AWD increased the irrigation water productivity by 64 %. However, each AWD cycle resulted in soil N mineralisation of about 3 kg N ha^{-1} and the loss of this nitrate-N upon rewetting. Total N losses increased with soil drying intensity and the number of AWD cycles and reached up to 30 kg ha^{-1}. While AWD appears to be an effective strategy to save irrigation water with no rice yield penalty, the observed nitrate losses point towards possible negative longer-term impacts on soil fertility and productivity in rice irrigation schemes of the dry Savannah zone.

Keywords: AWD, Burkina Faso, *Oryza sativa*, water productivity, water-saving technology

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Reviving Seed Sharing for Biodiversity Conservation Food Security and Ground Water Recharge

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Ground water protection and recharge is a major concern in West Africa, since water demand is likely to double in next thirty years with the growing population. Climate projections indicate that West Africa will be subjected to increased variability combined with a decline in rainfall. The GIZ Water Program ProSEHA investigated how ground water recharge can be improved alongside improvements of food security.

ProSEHA decided to test the improvement of rice production by increasing rice biodiversity and by encouraging site specific cultivation of old traditional rice varieties. ProSEHA collected a total of 25 varieties with different local names and the farmer-led testing and genetic tests validated 15 well distinguished varieties. Among these varieties were some with very good abilities to grow in deeper water and varieties with very low water needs for upland cultivation. Due to this wider adoption range, farmers were able to cultivate a larger proportion of their traditional watersheds. This increase in production area, helped that less land in the watershed banks remains idle, and thus prone to erosion, and consequently water recharge is enhanced.

167 farmer managed rice testing plots were evaluated. In the first year the plots were very small (<100 sqm) and increased over time as more seeds become available to plot sizes of up to 1 ha. All farmers tested various old varieties against a modern variety (mainly IR841). Farmers were invited to rate the relative performance of cultivars by observation and in addition precise yield measurements were taken. The trials were done without chemical fertilisers or other chemical plant protection measures.

The 4-years results showed local varieties performed at least equal (22 %) or even better (52 %) than modern varieties. Average yield for local rice varieties was 2.35 t ha^{-1} against 1.94 t ha^{-1} for modern varieties (+21 %). Farmer observation revealed that the local varieties offer a broader variation in crop cycle length, flooding and drought and pest resistance. Information and seed were diffused by annual seed sharing fares. The encouraging results led to an increase in participating farmers from below 20 in 2016 to 538 in 2019.

Keywords: Biodiversity, food security, seed exchange, water recharge

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Water Availability and its Interaction with Cropping Intensity Patterns of Rice-Based Systems in Southeast Asia

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Agricultural changes in cultivation patterns of rice-based systems in Southeast Asia have been investigated in the frame of the BMBF funded project "RICH-3P" coordinated by the University of Bonn. Six sites were considered, two in each of the listed countries: Cambodia, Myanmar and the Philippines. Alongside other changes, a shift from (rainy season) single rice cultivation to double rice cultivation (rainy and dry season) per year was observed at five out of six locations. For example, in the Central Dry Zone in Meiktila-Myanmar, 108 farmers (out of 160 respondents) indicated that they were producing rice twice a year in the present (2018), whereas about 20 years ago none of them were cultivating rice in both seasons. This development was made possible by the improved access to water in the respective regions. The present study aims to evaluate the external pressures and the (farming system) internal drivers leading to the change of single to double rice cropping. On the one hand, factors such as the improvement or installation of public irrigation infrastructure, cooperative work on municipal irrigation systems, advisory campaigns and assistance in the implementation of pumps, etc. are taken into consideration to explain the increase in water availability for farmers. On the other hand, we are investigating the thresholds of water quantity and availability that would lead farmers to definitely establish a second rice crop. For these purposes, apart from the evaluation of secondary sources, our work focuses on the acquisition and evaluation of optical satellite data (Landsat, Sentinel-2) from 1990 onwards in the corresponding study areas. A field-wise evaluation (polygon- and pixel-wise) of spatial and temporal water cover patterns during the flooding and transplanting status in the study areas will serve as proxy for the assessment of water availability and the determination of thresholds that induce farmers to shift from single to double rice cropping in the regions. The current state of research is taken into account and already implemented algorithms for the recognition of rice fields are applied using the data basis of the project, which also includes georeferenced boundaries of the farmers fields.

Keywords: Agricultural change, cropping patterns, irrigation, remote sensing, rice, water

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Introducing Sustainable Farming Practices in Rice Production to Myanmar's Transitioning Agriculture Sector

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Myanmar has experienced considerable economic and social changes since its political transition in 2011/2012. Its agriculture sector has demonstrated rapid intensification and modernisation. However, rice yield gaps remain an important issue with regard to food security. Reducing rice yield gaps in Myanmar could increase annual production and support efforts to establish food security. Therefore, agricultural best management practices (BMPs) were introduced to rice farmers in the Bago Region from 2012 on to increase sustainable rice production, reduce rice yield gaps, and countervail negative environmental impacts of agricultural intensification. The objective of this study was to determine rice farmers' agronomic development, socioeconomic situation, and livelihood changes due to the adoption of BMPs. Using a digital survey questionnaire application to collect household data, 160 farmers in eight villages were interviewed in 2012 and 2017. Data were analysed using uni- and multivariate statistics. Results showed that farmers who adopted BMPs such as improved rice varieties and optimised fertiliser application demonstrated significantly higher yields, income, and profitability while reducing inputs and labour. Furthermore, after five years significant socioeconomic differences were found between BMP adopters and non-adopters. The study showed that BMP adopters improved their livelihoods due to increased agricultural efficiency. However, yield productivity remains low in Myanmar compared to neighbouring countries. Poor access to inputs, high input prices, and little risk management are factors impeding improved agricultural profitability, and hence rural development. Furthermore, natural conditions as well as economic and social constraints play an important role in the way farmers are able to manage their land. Therefore, further development research and dissemination strategies for the implementation of appropriate sustainable technologies are needed to improve rice farming.

Keywords: Adoption, best management practices, dissemination, impact, Myanmar, rice production, sustainable agriculture

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Increasing Nutrition Security with Vertical Gardens – Testing Different Systems for Vegetable Production

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Vertical garden systems have been a largely urban phenomenon, used to cultivate food crops as well as ornamental species in areas that would not normally be suitable for plant growth. Vegetables grown in vertical garden systems can provide an important dietary supplement to households. However not much research has been done concerning systems' or varieties' production efficiency. We aimed to construct vertical garden systems that are low-cost, low-labour, and simple to make with materials available to all. The developed systems were tested for their (i) water holding capacity; (ii) produced biomass and yield; and (iii) which vegetable plant families could be suitable. The three systems designed and constructed were: the Second Wall, Planting Tower, and Bucket System, using three irrigation systems, i.e. cotton cloth, plastic tubes, and drip irrigation. The crops used in the systems represented four vegetable families: field peas (*Pisum sativum* L.; Fabaceae), African spinach (*Beta vulgaris* spp.; Amaranthaceae), black nightshade (*Solanum nigrum* L.; *Solanaceae*) and sukuma (*Brassica oleraceae* L.; Brassicaceae). Soil temperature and moisture were measured through implanted sensors, and yield was recorded. Six systems were constructed at three sites (2 system types per site) in schools located in Kapchorwa, Uganda. The systems and vegetables were compared using a mixed model. The Planting Tower had the highest and most constant water holding capacity, followed by the Second Wall. The soil temperatures of all three systems remained very constant, varying slightly between 18–23°C. The Planting Tower showed the highest yields for all cultivated species, followed by the Second Wall. The Bucket System produced the lowest yield for all vegetables. Both African spinach ($p = 0.020$) and black nightshade ($p = 0.049$) showed significant differences in yield depending on their placement in the system (at the top or the bottom), making them more sensitive to water content than sukuma and field peas. Overall, the systems performed well to produce a mix of nutrient-dense vegetables under different conditions in the field. We consider vertical gardens a promising option to increase surface area to produce a higher amount of diverse vegetables for the household, hence improving their food and nutrition security.

Keywords: Food and nutrition security, home garden, vegetables, vertical garden

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Opportunistic Adaptation of Conserved Moisture for Food Sustainability in Arid Zone

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Climate change coupled with multiple stressors have compelled subsistence farmers to develop location specific adaptation strategies to sustain their livelihoods in risk-prone ecosystems. A study on the opportunity of using conserved soil moisture for food and livelihood security and its adaptation in rural areas was carried out in Hemawas check dam with its catchment area in Pali district of Rajasthan, India. In arid zone (study zone) farmers are exposed to a set of multiple stressors making their subsistence vulnerable and to sustain their livelihood under these conditions, farmers have adopted specific options to diversify their livelihood options. In recent years as the consequence of climate change the terminal heat and rising temperature in the winter season have diverted farmers in Pali to adapt muskmelon in late winters. This is a short duration crop, cultivated with very least external inputs and moderate vulnerability. As the water dry up in the dam the land is first sown with short duration varieties of wheat, barley, oats, mustard and vegetables. The standing water is utilised for irrigation and as the land becomes devoid of water, muskmelon is grown in the conserved moisture. Normal ploughing is done to open up the soil and then manual sowing is done in the open spaces using local variety of muskmelon. Local plants are used as windbreaks to protect the small plants from cold winds in initial period and from hot winds in later period. Due to surplus moisture on top layer the seed germinates and as the plant grows its long root system draws water from the deeper layers of soil profile. After 15–20 days planking is done on the germinated seed and vines to close the open soil strata and this practice kills insects and parasites hiding in the crevices besides conserving the moisture in the soil layers. The soil is very rich in organic matter and nutrients thus on getting favourable conditions the vines yield ample fruits to sustain farmers livelihood. As no chemicals and fertilisers are used the crop is purely organic and the entire produce is sold at farm gate.

Keywords: Arid zone, moisture conservation, muskmelon, opportunistic adaptation, organic

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