



UNIVERSITY OF DAR ES SALAAM

A photograph of the entrance to the University of Dar es Salaam, featuring a large archway with the text 'KURUMAH HALL' above it. The building is white with a dark grid pattern on the walls. There are palm trees and other greenery in the foreground.

**The 3rd Annual Conference on
Research and Inclusive Development**

**Harnessing Research and Innovation for Sustainable
and Inclusive Development in Tanzania**

**11th - 12th November 2021
Dodoma, Tanzania**

BOOK OF ABSTRACTS

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Inclusive Development**

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Preamble

The University of Dar es Salaam has various fora through which researchers disseminate their research findings to national and international communities. One of such fora, which brings together researchers, policy-makers, practitioners, and other stakeholders, is the Annual Conference on Research and Inclusive Development. These conferences provide avenues and platforms for promoting the University visibility and for showcasing the research results initiatives geared towards addressing national and global development challenges. The first Conference on Research and Inclusive Development was held in 2018 and the second in 2019. However, in 2020 the conference was held in abeyance due to the global COVID-19 pandemic crisis.

The 3rd Conference on Research and Inclusive Development will be held at St. Gaspar Hotel, Dodoma from 11th to 12th November, 2021. The main theme is ‘**Harnessing Research and Innovation for Sustainable and Inclusive Development in Tanzania.**’ Like the past two conferences, the 3rd Annual Conference on Research and Inclusive Development aims to disseminate research findings of various research projects undertaken by UDSM staff and students benefiting from the bilateral research co-operation between the University of Dar es Salaam (UDSM) and 10 Swedish research institutions through the benevolent UDSM-Sida programme.

This Book of Abstracts presents summaries of research findings submitted for in-depth discussion at the conference. The abstracts are divided into 11 sections in line with the sub-themes of the conference. Section one consists of abstracts focusing on *Research Management*, whereas section two deals with *Engendering Agribusiness Entrepreneurship*. Section three presents abstracts on *Sustainable Tourism for Inclusive Development* and section four on *Food Security*. *Molecular Bioscience* abstracts feature in section five and section six those on *Applied Marine Sciences for Sustainable Fisheries and Aquaculture*. Section seven has abstracts on *Smart Energy Systems*, whereas sections eight, nine and ten present abstracts on *Sustainable Water Resources Management*, *Safe Drinking Water*, and *Sanitation Management*, respectively. Finally, the abstracts in section eleven are on *Mathematics in Higher Learning Institutions*. It is my sincere hope that conference participants and readers in general will find these abstracts useful in stimulating discussions not only during the 3rd Conference on Research and Inclusive Development,

but also in the furtherance of research-based solutions problems to contribute meaningfully to socio-economic development.

Prof. Bernadeta Killian
Deputy Vice Chancellor (Research)

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ABSTRACTS

Sub-Theme 1: Research Management

Participants' Governance in Research and Innovation in Tanzania: Their Perceived Roles, Functions and Ownership

Montanus C. Milanzi¹, Mwachija M. Kisoma¹ and Shauri O. Kinunda¹

Abstract

This critical documentary review interrogates the current National Research and Development Policy of 2010. It has established that, though the 2010 Policy seems useful, it is beset by a number of bottlenecks. Some of these deficiencies in the policy content and contexts include the non-inclusion of research participants as key stakeholders. Impliedly, the Policy appears supply-driven in its orientation. Thus, this critical review recommends that 360 degrees national science, technology and innovation policy is required and essential as a matter of urgency for Tanzania to transform her economy into a fully semi-industrial status.

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Strategic Innovation Management and Research Performance Among Academic Staff in Tanzania's Technical Higher Education Institutions

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Abstract

Several studies on the relationship between strategic management (SM) practices and organisational performance are widely documented in the business sector and not in the education sector. The reported studies evaluate the performance at the organisational and not at the individual level in terms of financial performance while excluding non-financial performance. Measuring performance in the business sector differs from how they measure performance in the education sector. Because of the inevitability of SM, this study assessed the influence of Strategic Innovation Management (SIM) practices on research performance among academic staff. This quantitative study used descriptive and explanatory survey designs. It gathered data using questionnaire administered to 277 academic staff sampled through stratified simple random technique. The gathered data were analysed using Descriptive Statistics and Multiple Linear Regressions. The study found that, academic staff are less involved to the small extent in the formulation of SM practices. Moreover, the study found strategic management practices to influence positively and significantly the research performance of academic staff. Therefore, the management of the technical higher education institutions (THEIs) should involve fully the academic staff in the formulation of strategic management practices for sustainable performance in research.

Keywords: SM Practices, Research, Performance

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Research Capacity among Academics in Tanzania's Universities

Simon Peter Ngalomba¹

Abstract

This study critically examined the research capacity of academic staff in the realisation of teaching, research and community services, the triad of university functions. It used simple random sampling technique to select the sample of 390 academic staff from three private universities in Tanzania. The sample selected including both females and males ranged from the humanities, natural sciences to the social sciences. The study found an acute shortage of research capacities among academic staff in private universities. One of the reasons behind this situation is that some of the private universities had been established with a philosophy that did not necessarily prioritise research aimed to address community problems (unlike public universities in Tanzania). Moreover, the recruitment and promotion criteria in private universities was found to be rarely attached to academics' research performance compared to their public counterparts, which adversely affected their capacity to meet their research obligations. Furthermore, the study found that organisational culture, leadership style and incentive mechanisms for research activities were instrumental in improving the academics' research performance. The paper, therefore, recommends that the research activities need prioritisation in both private and public institutions coupled with commensurate rewards to motivate academics to engage in research activities.

Keywords: Research, Reward, Incentives, Promotion criteria, Universities, Tanzania.

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Do They Think? Leveraging the Roles and Constraints of Think-tanks in Enhancing Industrialisation in the Globalised World: Evidence from Tanzania

Chakupewa Joseph Mpambije¹

Abstract

To maintain the recently attained low middle-income status, Tanzania needs to invest in further industrialisation of the economy as industries spur multiple growth in all socio-economic endeavours. Though several efforts have been made to facilitate industrial growth, the critical role that think-tanks (TTs) play in contributing to expediting the pace of industrialisation in developing countries has largely been overlooked. This is the central focus of this paper. Drawing on Whitemore and Knafel's integrative review methods, this paper posits that, in Tanzania, TTs have only marginally partaken in the industrialisation process in areas such as formulating better industrial policy, undertaking a niche in research for industrial development, upholding capacity-building among industrial stakeholders, and providing technical expertise through consultancy for industrial development. Though TTs have lightly participated in pushing for Tanzania's industrial path, they are still nascent. Efforts by TTs suffer from external and internal shocks including poor financial attraction, lack of qualified personnel and the low political support. This article contends that TTs have a crucial role to play in advancing industrial development particularly when stakeholders exert enough efforts to steer their growth. In this regard, the government needs to be committed to providing 1% of the GDP to research and development that will also ensure the think-tanks' sustainability.

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**Sub-Theme 2:
Engendering Agribusiness
Entrepreneurship**

Offshore Korean Saemaul Undong Project: A Comparison of External and Internal Initiatives in Rural Inclusiveness

Robert Suphian¹ and Dev Jani²

Abstract

The phenomenal developmental phase experienced by South Korea in the 1980s to 1990s that transformed the country from an agrarian to an industrial powerhouse is globally being applauded and credited thanks to the *Saemaul Undong* movement. The success of the Korean rural development model (*Saemaul Undong*) in South Korea has led to its adoption by Korean developmental organisations in overseas developing world, for example, among Sub-Saharan African countries. Yet, the contextual differences between rural areas that could influence the initiatives have yet to be explored and compared. This study, therefore, aimed to compare rural agricultural projects' relevance, inclusiveness, project implementation, and local satisfaction between Korean Overseas International Co-operation Agency (KOICA) Tanzania-initiated rural projects and local individual initiated projects. Data collection focused on local residents' perception of the projects using structured questionnaires that yielded 288 usable data-sets. Independent sample t-tests revealed that local individual-initiated projects were significantly positive when evaluated with respect to the four dimensions compared to the other group of ventures. Implicitly, projects initiated by a local person are more inclusive than those initiated by developmental agencies that are perceived to be too removed from the locality and were largely out-of-context. The study findings offer insights into the management of agricultural rural development projects by factoring in contextual differences.

Keywords: Community, Project management, Inclusion, Korea-Tanzania, Rural

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Women's Rural Agribusiness-Entrepreneurship: Beyond Farming and Processing

Merezia Wilson^{a1}, Lettice K. Rutashobya^a, Johan Gaddefors^b,
Lemayon Melyoki^a and Opira Otto^b

Abstract

Studies have portrayed women as key players in the agricultural sector in almost all rural areas, especially in Sub-Saharan Africa. Indeed, women have contributed more than half of the labour force in agriculture and, in some cases, their engagement in agricultural activities accounted for 98% of their economic activities. Yet, most of these studies have been unable to capture the entrepreneurial side of these women's engagements in agricultural-related activities. In fact, few of those studies, which have been conducted on entrepreneurship, have focused largely on the on-farm businesses and limited processing of agricultural produces. As a result, only a narrowed view of women's rural entrepreneurial engagements has emerged. This narrow view inevitably understates their contribution to socio-economic development. This paper, therefore, seeks to address this problem by providing insights into women's engagements beyond the traditionally-recognised activities. This qualitative study generated data from 25 interviews and three FGDs. Particularly, the study investigated the different entrepreneurial activities in which women are engaged. The study found women to be generally engaged in rural entrepreneurial engagements beyond farming and processing. Specifically, there were efforts to organise women to engage more in agribusiness, get through negative societal perceptions of women engagements in agribusiness, overcome religious constraints, get permission from husbands, voluntarily partake in environmental conservation community works, engage in place branding and place bridging. The outcome of these engagements alongside farming and processing contributed considerably positively to socio-cultural and spatial transformation. These findings challenge the conventional economic orientations of entrepreneurship as they reveal that women engage in a wider range of rural entrepreneurial activities beyond farming and processing than previously thought. Oftentimes, these

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engagements are usually glossed over, without being connected directly to the farming or processing businesses. They are more identified with care for other women, community wellbeing and resources and infrastructure sustainability, which downplay their otherwise crucial socio-economic role. The study concludes that, to communicate effectively the change phenomenon, which is crucial in entrepreneurship research, we must consider the multiplicity of entrepreneurship versions, make them visible and learn more about how they complement or contradict each other.

Keywords: Rural, Entrepreneurship, Agriculture, Agribusiness, Women

Gendered Participation in Rice Farming in Kyela, Tanzania

Mesia Ilomo^{a,b,1}, Johanna Bergman-Lodin^b, Lettice Kinunda Rutashobya^a,
Katarina Pettersson^b, Esther K. Ishengoma^a

Abstract

This paper examines the ways and rationale for gendered participation in rice farming in Kyela, south-western of Tanzania, a source of the most preferred rice in the country. Rice, the third most important staple crop in Tanzania after maize and cassava is transforming into a cash crop. Yet, less is documented on the extent and rationale for the participation of women and men in rice farming and whether the ongoing transformation alters their participation. The paper draws on 54 interviews and eight focus groups with farmers and traders collected in 2017 and 2018. The empirical materials included verbatim transcripts and participants' perceptions in numeric form that were thematically and descriptively analysed, respectively. We found that none of the farming tasks is exclusively handled by either women or men. However, we found that women mainly handled less mechanised and perceived light tasks such as weeding, threshing and drying, whereas men often featured in more mechanised, technical, and perceived heavy tasks such as land preparations and chemical application. The tasks-level analysis has revealed some variations of women's and men's participation in rice farming and enabled probing for specific reasons for (non) participation in a task. The norms, personal factors, economic, and spatial factors seem to influence gendered participation in the rice farming. Our study, therefore, can inform future research, and offer insights for targeted agricultural interventions.

Keywords: Doing gender, Farming, Rice, Tanzania

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Circumventing Group Dynamics and Gender Stereotypes in Women Groups: Lessons from Performing Rural Women's Collective Enterprises in Tanzania

Mohamed Semkunde^{a,b,1}, Elly Tumsifu^a, Lettice Kinunda Rutashobya^a, Goodluck Charles^a, Linley Chiwona-Karlun^b

Abstract

In recent years, self-help groups have shown that they have the potential of increasing women's engagement in rural entrepreneurship. However, there are also challenges, as a collective reputation increases incentives to free ride. Members might take advantage of the better performance of the group and achieve entrepreneurial results without fulfilling their obligations. This paper, therefore, explores how rural women circumvent group dynamics and stereotypes while engaging in rural entrepreneurship. Using the concept of local embeddedness combined with the group dynamics theory, the paper builds on a case study of two groups engaged in rice production, processing and marketing. It draws on in-depth interviews with four members for each group, two focus group discussions with eight group members for each group and four semi-structured interviews with the chair and secretary of the two groups in northern parts of Tanzania. The two case studies reveal that both internal and external forces have stimulated continuous mechanisms towards navigating through complex patriarchal structured communities. The findings indicate that collective needs for achievement among group members, fear of failure driven by gender stereotypes in the local context, competition among groups and internal control mechanisms to group dynamics have fuelled group performance in the study areas. However, the challenges still exist as the successful members face household burdens and conflicts.

Keywords: Tanzania, Self-help groups, Group Dynamics, Rural enterprises, Local embedded.

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Serial and Portfolio Female Entrepreneurs in Rural Areas: Motivations, Outcomes and Benefits

Lettice Kinunda-Rutashobya¹& Linley Chiwona-Karltun²

Abstract

In Sub-Saharan Africa (SSA) female entrepreneurs are increasingly serving as “drivers of African prosperity,” as “rising stars of the economies” and as an “untapped source of economic growth.” In fact, more women in rural SSA own and manage fewer businesses than men due to infrastructural deficiencies, institutional, policy and negative cultural norms. We argue that promoting rural entrepreneurship would economically empower rural women, foster rural development and reduce poverty in the process. Key to understanding rural entrepreneurship development is the role of entrepreneurial motivation in comprehending entrepreneurial outcomes. We draw from Sokol’s entrepreneurial event formation and Ajzen’s theory of planned behaviour to explore the motivation of serial and portfolio female entrepreneurs in rural Tanzania and Malawi. Studies on women entrepreneurs account for less than 10% of all research in the field, particularly serial and portfolio ventures research. The study used six in-depth case studies of serial and portfolio rural entrepreneurs from Tanzania and Malawi. The number of cases employed in the study is consistent with the literature that insist on four and 10 as a good fit for making analytical generalisations. Our findings of rural women entrepreneurs show that it is the critical moments that motivate serial and portfolio entrepreneurs’ start-ups. Significantly, women’s motivation to start businesses is not static, as this evolves/changes with context and life experiences. Initially, rural women’s perceived desirability and propensity to act upon opportunities influenced their entrepreneurial intentions, and caused most of them to leave salaried employment to risk starting a/or businesses. Additionally, women did not implement serial or portfolio ventures out of failure of previous businesses, as the dominant narrative claims. Rather, their ventures largely resulted from a perceived desire to grow their businesses to meet basic and growth needs. Narratives of their critical moments revealed, for example, that a loss of a spouse led women to establish ventures aimed

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to meet household demands and educational needs of their children. Market challenges influenced them to establish other ventures, which was consistent with opportunity-driven entrepreneurship. Thirdly, collective agency and networks played a crucial role in the women's entrepreneurial process. Serial entrepreneurship affirmed the women's capabilities especially in rural entrepreneurship. We conclude that necessity and opportunity motivations are not mutually exclusive. The pull-and-push factors can appear together. Thus, the promotion of collective agency and networks amongst rural women entrepreneurs, which can go a long way in enhancing sustainable rural development, is essential.

Keywords: Serial and Portfolio Female entrepreneurs, Motivations, Rural Entrepreneurship, Rural Development, Africa

Rural Entrepreneurship and the Context: Navigating Contextual Barriers through Women's Groups

Mohamed Semkunde^{1b}, Elly Tumsifu^a, Goodluck Charles^a, Johan Gadd-efors^b, Linley Chiwona-Karlton^b

Abstract

This study examines how women's groups help them to navigate context-related barriers to their engagement in rural entrepreneurship. The paper combines the contextualisation of entrepreneurship framework and the feminist separatist theory to describe how women's groups in patriarchal rural communities enable women to circumvent context-related barriers and actively engage in rural entrepreneurship. Based on a case study of 12 women's groups engaged in paddy farming, rice processing, and marketing in rural Tanzania, this study draws on semi-structured interviews with 46 women, four focus group discussions, four in-depth key informant interviews, and non-participant observation. We found that rural women face context-related barriers that hinder them from engaging effectively in rural entrepreneurship. Specifically, limited access to farmlands and profitable markets, lack of business networks, limited time, poverty, and insufficient financial resources constrain women's engagement in entrepreneurship. To overcome these contextual barriers, rural women have organised themselves into groups to gain access to business services, business-related training, grants, and business networks. This study offers new insights into the role of women's groups in navigating gender-related constraints that hinder women from participating in rural entrepreneurship within the patriarchal context of low-income countries. Thus, new perceptions for the gender and rural entrepreneurship theory and the policy implications thereof are proffered.

Keywords: Context, Rural Entrepreneurship, Kahama Rural, Shinyanga Rural, Women's Groups

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Exploring Governance, Transaction Costs and Networks in Linking Horticultural Smallholders and Tourist Hotels

Winnie Nguni

Abstract

The study explores value chain governance, transaction costs and networks in linking horticultural smallholders and tourist hotels. It draws evidence from horticultural-tourism value chain in Tanzania as a case study. In-depth interviews with the tourist hotels' procurement managers/chefs/managers, intermediaries, individual smallholders, key informants from farmer organizations/groups and government agencies, focus group discussions, observation and documentary review were conducted. Collected data was qualitatively analysed using pattern matching technique. The results show there are critical transaction costs and certain nature of networks, other than 'mundane' transaction costs proposed by Global Value Chain framework that determine different governance structures in local context as compared to global context. These in turn determine smallholders' competitiveness in accessing in-country high value food markets, such as tourist hotels. Thus strategies to strengthen the linkage between horticultural smallholder and tourist hotels must first consider smallholders' self-driven efforts to form their own networks.

Keywords: Governance, Transaction Costs, Networks, Horticulture, Smallholders and Tourist Hotels

**Sub-Theme 3:
Sustainable Tourism for Inclusive
Development**

Potential Wildlife Tourism Products in the Selected Lakeside Regions

Wineaster Anderson¹, Cuthbert L. Nahonyo² and Ruth H. J. Lugwisha³

Abstract

The main objective of this study was to identify and map out the existing and potential wildlife (and related) tourist products and attractions in three regions of Kagera, Geita and Mwanza. A survey of wildlife tourist products and attractions, which involved direct observation through site visits, interviews, focus group discussions, key informants' interviews were conducted in March 2021. In addition, desk research included a variety of reports, documents and the regional and district profiles. The findings suggest that wildlife tourism in the western lake zone is manifested in three levels: State, non-state, and traditional or community level. The state level wildlife tourism involves national projects such as national parks, forest reserves and nature reserves. In fact, it is the most significant component as it attracts many visitors due to the presence of many attractions in the forests and protected areas. The non-state level wildlife tourism is mostly private undertakings including wildlife ranches and wildlife farms. This level is yet to be developed as currently only few people have invested in the business. The private sector level is also connected to the intangible products of tourism mainly comprising the visitor services such as accommodation, transport and tour guiding and interpretation for visitors. Tourism services also need significant improvement. The third level of wildlife tourism is found in traditional groups and/or communities. Here there are people practising cultural dances, which often involve the use of wild animals such as hyenas, monkeys, porcupines, and pythons. The use of animals depends on the ethic line within specific clans. These cultural dances need further development and improvement to make them more marketable and appreciated by visitors. Noticeably, there is no direct collaboration/linkage in terms of connecting tourist activities available in one region/district with other activities happening in other regions to create a network (tourist circuit) which will be more meaningful in terms increasing

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and developing tourist products and their marketing. Also, the linkages among the three levels of wildlife tourism (state, non-state and community) in the zone are poorly interconnected. There is therefore a need to develop the tourist products and attractions to marketable levels in addition to creating linkages between different tourism levels and regions/districts to boost the wildlife tourism and local businesses through the multiplier effect of the tourism business.

Keywords: Wildlife, Tourism, Lakeside, Mwanza, Kagera, Geita

Contesting COVID-19 to Recover Tourism: Actors' Responses in Tanzania

Godwin Adiel Lema¹

Abstract

COVID-19 is increasingly affecting tourism as destinations worldwide struggle to recover. Yet, countries vary and respond differently. Processes specific localities and nations for rescuing tourism from the pandemic are less clear. This paper examines the actors' responses to reviving tourism sharing experiences in Tanzania. An 11-month study of tourism sector recovery in 2020 was based on media review, surveys, interviews and analysis of tourist arrivals statistics and the trend of revenue collection. Media discourse analysis shows that the country monitored first infections cases and deaths associated with coronavirus to understand their impacts on health and economic systems. Air space shut in March and April significantly halting international tourists' arrivals, resulting in huge revenue loss with heightened unemployment. Consistently from May COVID-19 tourism crisis is the gradual resolution entailing adopting standards operating procedures. These measures are, arguably, effective as a sharp decline of arrivals was witnessed in April while a gradual tourist arrivals increase was observed after reopening the country's international gateways. The findings infer that theoretically varied actors' responses are expected to determine the nature and pace of tourism recovery from COVID 19 crisis in specific nations.

Keywords: COVID-19 Tourism, Actors' responses, Recovery, Tanzania

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Social Media Marketing of Tanzania's Souvenir Sellers: Self-Inclusive or Exclusive?

By Maximilian Mfaume & Dev Jani

Abstract

Inclusion in the mainstream tourism value chain has captured the interest of tourism researchers and destination managers as it serves as a means towards tourism sustainability. However, research focusing on inclusion strategies used by souvenir sellers particularly in a less developing context of Africa are missing. To fill the knowledge gap, the study appraised the social media marketing strategies Tanzania souvenir sellers used relative to those of South Korea where cultural tourism artifacts play a significant role in the tourism industry. The data was collected from 70 Instagram accounts of Tanzanian and South Korean souvenir sellers. The accounts (sample units) were sampled using a snowball non-probability technique. Both quantitative and qualitative data were collected with number of posts, followers, posts, and replies representing the quantitative data while the nature and type of description used for the souvenirs being the qualitative data. The data was analysed quantitatively using a descriptive method and t-tests. Meanwhile, the qualitative data were subjected to content analysis. The results suggest the presence of a significant differences between Tanzanians and South Koreans with respect to number of posts, followers, date of posts, and likes with Korean souvenirs sellers ahead of their Tanzanian counterparts. Based on the narratives and types of stories souvenir sellers used to describe their products, South Korean sellers were more meticulous and detailed storytellers than their Tanzanian counterparts who barely use stories. Implicitly, Tanzanian souvenirs exclude themselves as proactive tourism product sellers compared to their Korean counterparts who are self-inclusive in the tourism value chain. As souvenirs are symbolic products serving destination experiences, the accompanying stories are crucial to serving their intended purpose. If there are no symbolism accompanying souvenirs like those from Tanzanian sellers, the souvenirs are just like any functional commodities. Tanzania souvenir sellers, therefore, should avoid selling mere commodities and need to invest in expanding their skills and social media advertising tactics, particularly learning and using the cultural and symbolic narratives in communicating with the potential buyers.

Keywords: Inclusive, Souvenir, Sellers, Tanzania, South Korea, Comparative

Factors Affecting the Tanzania Consumers' Post-Transaction Sales EFD Receipts Claims : Evidence from EFD Sale Receipts in Dar es Salaam

Juma James Masele¹ & Leonard Justine Mutiba²

Abstract

Though non-compliance is a major problem for many tax administrations, record-keeping remains a big challenge for many enterprises in developing countries. Thus, the introduction of EFDs aimed to combat the non-compliance problem so that sales records could easily be sent directly to the revenue authorities, hence solving the problem of incorrect tax base establishment in addition to improving the problems related to record-keeping among entrepreneurs. Yet, though users are expected to claim for receipts after transactions—as reference to the purchased items and tax relayed to TRA, evidence indicates that most of the consumers choose not to do so. Bins and sacks full of EFD receipts are evidences in shopping sites including petrol stations and supermarkets. This discrepancy triggered the interest to answer the question: “*Why don't some customers take sales EFD receipts after transactions?*” Using the theory of planned behaviour (TPB), this study investigated the factors preventing taxpayers from claiming EFD receipts after transaction. Specifically, the study sought to determine influence of facilitating conditions, individual attitude, subjective norms, perceived behavioural control and perceived receipts validity on customers' concerns towards claiming for EFD receipts after transactions. Data was collected from 371 respondents drawn from Dar es Salaam city. The study found that facilitative conditions, individual attitude, subjective norms, perceived behavioural control and perceived receipt validity have a positive effect on the intention to claim sales receipt after transactions. Efforts should, therefore, be directed towards winning over consumers by persuading them on the importance of paying taxes in national development, including their playing respective roles as citizens in demanding EFD receipts for each of their transactions. The government on its part through the TRA must produce policies and regulations aimed to reinforce customers' behaviours to claim receipts for each transaction they make.

Keywords: Consumer, EFD, EFD receipts, Tax compliance, Transactions

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‘We have what we experience’: Local People’s Inclusiveness in Destination Tourism Exchanges

Nelly Samson Maliva¹

Abstract

This article shows how the inclusiveness of local people living in tourist destinations materialise through their participation in tourism exchanges directly and remotely. It uses the Zanzibar destination as a case where there are close interactions between tourism activities and local people’s lives. Using in-depth interviews, with local people, and representatives from governmental and non-governmental institutions as well as from tourism-related enterprises, the study has captured people’s experiences through their involvement in tourism. The local people’s perceptions of tourism has been changing as they increasingly interact with tourism activities by actively taking advantage of tourism-engendered opportunities. They reported that their experiences evidenced in their participation have been influenced by their culture, their link with the government, and tourism investors’ perceptions of their behaviours. Also, the study found that the freedom of the local people to decide tends to lead to the creation of groups with both positive and negative perceptions of tourism. Overall, this paper has contributed to theory and gives input to policy-makers for them to design customised policies aimed to support local people in tourism destinations.

Keywords: Pro-poor tourism, Residents’ experience, Investors’ perception, Tanzania

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Conservation and Adaptive Management of Globally Significant Cultural Heritage Assets in the Lake Eyasi Basin, Northern Tanzania

Pastory Magayane Bushozi¹

Abstract

Lake Eyasi basin in northern Tanzania is one of the few key regions in Africa that offer crucial information on the origin, spread and peopling of the world. Material culture from this region sheds significant light on the origin and development of modern human behaviour. Such cultural heritage assets contain dense, stratified and continuous archaeological records spanning from the Middle Pleistocene to Holocene periods. These archaeological records also provide an opportunity to investigate trends in technological change, past diets, symbolic aspects and other traits of cognitive thoughts. For the long-term, these cultural relics together with environmental trajectories have been managed through traditionally-based non-legislative system ordered through traditional norms and values. However, such arrangements were interrupted by legislative heritage management systems stressing law enforcement and economic outputs during the colonial and post-colonial periods. This paper discusses sustainable solutions and guidelines on how to co-manage manage such cultural assets and the surrounding environment. The intention of employing co-management systems is to develop a highly focused mission for sustainable management and use of cultural assets, reduction of vulnerability to climate change, enhancement of sustainable rural development and contribution to poverty eradication through tourism.

Key words: Cultural heritage assets, Sustainable conservation, Co-management system

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Potential Cultural Tourist Attractions in Geita, Kagera and Mwanza

Theresia Busagara¹, Noel Lwoga², Wineaster Anderson³ and Zahor Zahor⁴

Abstract

Tanzania is one of the countries with abundant cultural heritage resources spread out across the country. However, the development and promotion of many of these attractions for tourism purposes remain limited to the Northern and Coastal Tourism Circuits, leaving the enormous rich heritage resources in other parts, especially in the Lake Zone, undeveloped, deteriorating and in risk of disappearing. This paper aims to explore and map the cultural heritage resources that are potential cultural tourism attractions in the Lake Zone by focusing on Geita, Kagera and Mwanza regions. The study employed key informant interviews with site personnel, local tour guides and communities, and Focus Group Discussions (FGDs) and observations to collect requisite data. In addition, site pictures and GPS location points were taken to provide pictorial evidence of the attractions and their tourism potentials. Descriptive analysis was employed to examine and present the data. The findings confirm that the Lake Zone is rich in cultural heritage resources with an enormous potential for fostering tourism and, thus, can be developed as cultural tourist attractions. On the other hand, the findings indicate the absence of adequate tourism institutional frameworks, and tourism facilities and superstructures for enhancing tourist access and consumption of the cultural attractions. By identifying and mapping market-based tourism potentials and providing recommendations towards their development and promotion, this study contributes to the tourism development process in the Lake Zone, specifically, and Tanzania. Moreover, it serves as a catalyst for tourism policy and decision makers to include cultural attractions from the overlooked localities in the overall tourism development plan for diversification and sustainability.

Keywords: Cultural Tourism, Lakeside, Geita, Kagera, Mwanza

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Education and Health as Components of Inclusive Tourism Development in Mwanza, Geita and Kagera: The Use of Geographical Information Systems (GIS)

Zahor Zahor¹, Leonard Mitti² and Wineaster Anderson³

Abstract

This study applied Geographical Information Systems (GIS) to identify potential tourist attractions, facilities and services and determine spatial accessibility of health facilities and academic institutions in connection with the areas of interest. The study examines the practicality, possibility, suitability, desirability and compatibility of education and health as integral components of inclusive tourism development on the lakeside in Mwanza, Kagera and Geita. Data were collected using interviews, focus group discussions, field observation, handheld GPS, mobile GPS, and satellite images provided by Google Maps TM and Open Street Maps. The target group were training providers, key stakeholders in health industry as well as tour operators. The study used both spatial and non-spatial techniques such as Microsoft Excel, SPSS, as well as GIS to analyse the data, and tables, boxes and maps to present the findings. The results of this study reveal that education availed under various levels lacks essential soft skills such as language proficiency, customer service, display of professionalism and lack of in-depth understanding of products existing in the marketplace. Still most of the curricula do not have entrepreneurship as one of core subjects in their modules; therefore, graduates lack skills to use their education for self-employment within and outside the tourism industry. The mode of education delivery is still old-fashioned; the use of ICT is quite limited if not entirely absent. Innovation and use of ICT are key in the changing tourism industry. Medical Tourism in the Lakeside regions happens to be a delayed venture given the tourist attractions found in the area. There is also still a need for dynamic private healthcare facilities within the zone to play a role in the medical tourism industry.

Keywords: Education, Health, Inclusive Tourism, Mwanza, Geita and Kagera

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Corporate Sustainability and Financial Performance of Tourism Firms in Tanzania: The Mediating Role of Firm Capabilities

By Suluo Said¹, Lena Mossberg^b and Wineaster Anderson^a

Abstract

This study examines the mediating effect of firms' capabilities on the effect of sustainability initiatives on financial performance of tourism firms in Tanzania. Data was collected using a questionnaire administered with managers of tour operators and accommodation firms operating in Tanzania and structural equation modelling was used to analyse the structural model. The results show that strategic proactivity capability mediates the effect of corporate sustainability initiatives (community, economy, and eco-efficiency) and firm financial performance while the mediation effect of collaboration capability was not supported. The results suggest that firms need to prioritise corporate sustainability initiatives with immediate benefits to the external community while developing and applying strategic proactive stance for corporate sustainability initiatives with little immediate benefits for the external community.

Key Words: Corporate Sustainability, Financial Performance, Firm Capabilities, Tourism, Tanzania, Sub Saharan Africa

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Service Innovation: Does Tourist Interaction and Feedback Matter?

Theresia Busagara¹, Neema Mori¹, Lena Mossberg², Tommy Anderson² and Dev Jani³,

Abstract

Purpose - Tourist interactions with service providers facilitates tourism experience. Yet, the knowledge on the effects obtainable from these interactions in conjunction with the tourist feedback is slightly limited. Thus, this study examined the direct and indirect relationships between tourist interactions and tourist feedback on service innovation. This study is based on survey data drawn from a sample of 290 tourism firms. To test the direct and indirect relationships between tourist interactions and tourist feedback in promoting service innovation, the study used the Structural Equation Modelling (SEM) in the Partial Least Square method while adopting measurement scales from the previous studies. The findings reveal that both tourist interactions and tourist feedback have positive and significant relationship in fostering service innovation. In the direct relationship, tourist interactions indicated a strong positive relationship with service innovation; meanwhile, the results also suggest a partial mediation of tourist feedback on tourist interactions and service innovation. The results of this study enrich the service industry particularly on how to capitalise on interactions and feedback to generate new services. Thus, managers ought to set strategies aimed improve interactions as means for fostering good service innovation practices. In addition, managers should emphasise on strong interactions with their customers in all stages of service production. This study offers an extension of the theoretical understanding in interactions as applied in the service dominant logic. Apart from the exchange focus, interactions can serve as information sources for service innovation across firms. Thus, this study also contributes to the theoretical framework of co-creation and service innovation.

Key words: Interactions, Feedback, Service Innovation and Tourism

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Promotion Strategies and Tourists' Hotels Performance in Tanzania. Insight from Dar es Salaam City Based Tourists' Hotels.

Omari K. Mbura and Simith J. Sanga

Abstract

This piece of writing examines the role of promotion strategies on tourists' hotels performance with insight from the tourist hotels in the largest commercial city of Tanzania, Dar es Salaam. Precisely, it dwells on the extent to which key promo tools of advertising efforts, sales promotion, direct marketing, public relation and personal selling influences tourists' hotels performance. Informed by Hierarchy of Effect, Relationship Marketing and Behavioral Learning theories, data were collected randomly from 80 managers/ owners from tourists' hotels through structured questionnaires. Moreover, 3 key informants were purposively contacted for in depth interview. Through multiple regression analysis, it was ascertained that advertising, sales promotion, direct marketing and public relation were strong predictors of tourists' hotels performance. Personal selling had positive, but insignificant influence on tourists' hotels performance. The article recommends the tourists' hotels management to capitalize mostly on the four most influencing promotion actors to the tourists' hotels performance. More emphasis should be placed on posters, print media, and radio categories, which appear to be the most influencing for advertising, while coupons, discounts and contests actors outperform other sales promotion attributes. Finally, Internet, telephone and telemarketing should be emphasized for direct marketing while social media, business events and press release, should be utilized for public relation.

The Nexus between Promotion Strategies and Tourists' Hotels Performance in Tanzania.

Omari Khalifa Mbura¹

Abstract

The paper examines the role of promotion strategies on tourists' hotels performance in Tanzania using Dar es Salaam City as a study platform. Specifically, the paper determines the extent to which advertising efforts, sales promotion, direct marketing, public relation and personal selling influences to tourists' hotels performance. The study was guided by three theories namely, Hierarchy of Effect theory, Relationship Marketing theory and Behavioral Learning theory. Data were collected randomly from 80 managers/ owners from tourists' hotels through structured questionnaires. Moreover, 3 key informants were purposively contacted for in depth interview. The multiple regression analysis findings show that advertising, sales promotion, direct marketing and public relation had positive and significant influence on tourists' hotels performance. Personal selling had positive, but insignificant influence on tourists' hotels performance. The article recommends for the tourists' hotels management to work out for the four most influencing factors to the tourists' hotels performance. More emphasis should be placed on posters, print media, and radio which appear to be the most influencing attributes for advertising. Moreover, emphasis on coupons, discounts and contests should be placed for sales promotion. Furthermore, emphasis should be put on Internet, telephone and telemarketing for direct marketing and lastly emphasis be placed on social media, business events and press release for public

Sub-Theme 4: Food Security

Towards Meeting the Food Demand for 2050 through Urban Integrated Aquaculture-Agriculture

Aulath Mzamilu Mustafa¹, Paul O. Onyango² and Prof. Mwita Chacha²

Abstract

The Food and Agricultural Organisation (FAO) of the United Nations estimates that by 2050, the global demand for food, feed and fibre is expected to grow by 70 percent. This growth will be in response to the high rate of population growth estimated to rise to 9.1. Most of these people will be found in the urban centres of developing countries. The consequence of this ever-expanding urban population poses a challenge to finite rich agricultural land available. In fact, as we draw closer to 2050 there will be minimal arable land available. As space is an issue, we argue that urban population must be involved rigorously in an integrated aquaculture agriculture (IAA). IAA allows for the use an alternative growth medium fertilised by water from fishpond. Our position is grounded on an experiment we carried out at the University of Dar es Salaam where we assessed the growth, yield and financial viability of integrating amaranths (*Amaranthus hybridus*) and tomato (*Solanum lycopersicum*) grown on coco-pith compost. Coco-pith was fertilised with different manure combination comprising pondwater from African catfish (*Clarias gariepinus*), combined with cow dung and chicken manure. The results indicate that there was no significant difference in amaranth growth ($p > 0.01$) among different manure compositions; meanwhile, tomato plant growth parameters were significantly different ($p < 2.2e-16$). Moreover, African catfish in the ponds had mean weight of 0.395 ± 0.022 kg and net yield of 11.37 tons' ha⁻¹ at 8 months' period, with NPV of TZS 967,347.82 and IRR of 23% for the first 10 years. The highest amaranths yield was obtained from coco-pith composted with pondwater mixed with chicken-cow manure, which had comparably high NPV of TZS5, 592,442 and IRR of 23%. Tomato's highest yield was harvested from those grown in soil (control) with NPV of TZS 8,356,371.74 and IRR of 27% followed by tomato grown on treatment 4 (coco-pith composted with mixed chicken-cow manure) with NPV of 7,542,763.23 and IRR of 25% all at 7% discounting

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rate for 10 years. We, therefore, argue that amaranths and tomato farming on coco-pith composted with fishpond water and mixed with chicken and cow manure yields equally high output, thus making coco-pith the best alternative growth media to soil.

The Potential of Lactic Acid Bacteria (Lab) Isolated from Tuna and Tuna-Like Species for Seafood Preservation

Jerry Mang'ena*^{1,3,4}, Sylvester Lyantagaye^{2,3} and Lulu Tunu Kaaya¹

Abstract

This study investigated the potential of Lactic Acid Bacteria (LAB) isolated from tuna and tuna-like species for seafood preservation in Tanzania as an alternative to current preservation methods in a bid to address the problem of fish post-harvest losses. To achieve this objective, LAB was obtained from tuna and tuna-like species and then identified using morphological and molecular techniques using the 16srRNA gene with maximum composite likelihood for phylogenetic analysis. The Identified LAB were assessed for antimicrobial compound produced (lactic acid, diacetyl and hydrogen peroxide). Finally, the higher antimicrobial compound producing LABs were examined for microbial and sensory changes for the LAB preservation time of seafood at different modes of application (spraying vs immersed), different packing methods (vacuum packed vs air-packed), and preservation temperature (Freezes, less than 0 °C), refrigeration (4 °C) and room temperature 23 ± 10°C) for a duration of up to 10 days. The results showed that LAB isolated from tuna and tuna-like species were *Enterococcus duran* (MW165443 and MW165446), *Enterococcus faecium* (MW165444), *Enterococcus thailandicus* (MW165441) and *Pediococcus pentosaceus* (MW165445). *Pediococcus pentosaceus* and *Enterococcus thailandicus* had higher production of LA, Diacetyl and Hydrogen peroxide. There was a significant difference on the microbial load in fish samples treated with different treatments by *Pediococcus pentosaceus* and *Enterococcus thailandicus*. Moreover, the sensory evaluation shows that fish preserved under *Pediococcus pentosaceus* could extend the shelf-life of fish for up to 5 days. This study's results imply that marine-based *Pediococcus pentosaceus* from yellowfin tuna can serve as a candidate of fish bio-preservation.

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Market-oriented Agriculture and Household Diet Diversity and Nutrition in Tanzania

Martin Julius Chegere¹ and Monica Sebastian Kauky²

Abstract

Consumption of appropriate amounts and high-quality variety of food that provides sufficient energy and nutrients the body requires is one of the sustainable ways of addressing malnutrition. However, the consumption of nutrient-rich and diverse diets is sensitive to changes in household income and food prices, especially for net buying rural agricultural households. Using the three waves of the Tanzania National Panel Survey data, this paper employs panel data models and probit model on pooled cross-sectional data to analyse the linkage between market-oriented agriculture, dietary diversity and nutrition status in rural Tanzania. The study found that market orientation has a significant effect on dietary diversity for lower income groups, but an indirect effect on overall income for the whole sample. Moreover, household dietary diversity has a significant simple correlation with lower probability of child stunting, which becomes insignificant when the overall income is controlled. On the other hand, female education levels and overall income levels have significant effects on diet diversity and child nutrition. These factors entail a judicious use of money from sales of agricultural products as well as the embodiment of other factors for improving dietary diversity and nutrition status.

Key words: Market oriented agriculture, Dietary diversity, Nutritional status, Panel data, Tanzania

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The Impact of Hermetic Storage Bag Supply and Training on Food Security in Tanzania

Martin Julius Chegere¹ · Razack Lokina² · Agnes G. Mwakaje³

Abstract

Reduction of post-harvest loss (PHL) can play a key role in complementing efforts aimed to address food security challenges. This paper used data from 390 small-scale maize farmers in Kilosa, Tanzania to analyse the impact of post-harvest management training and the supply of hermetic bags on food insecurity status in a framed field experiment setting using two treatments. In the first treatment group, farmers received training on post-harvest management, and in the second they underwent the same training as the first treatment group but were additionally provided with hermetic bags for storing maize. Our estimations show that the interventions reduced maize PHL and household food insecurity. Specifically, the intervention combining training and the supply of hermetic bags abated maize PHL by 53%, whereas the training intervention alone abated PHL by only 26%. Moreover, the intervention combining training and the supply of hermetic bags reduced the household food insecurity access scale (HFIAS) score by 30.9% whereas the training intervention alone reduced it by 10.8% relative to the control group. The two interventions also lowered the probability of treated households experiencing moderate or severe food insecurity, and increased the probability of the households being food secure or mildly insecure relative to the control group. Notably, the intervention, which combined training and the supply of hermetic bags, had a significantly larger impact than the one providing training only. These results imply that more investment should be directed towards interventions aimed to reduce PHL to complement efforts for improving food security. They also suggest possible affordable interventions for reducing maize PHL in addition to underscoring the importance of providing material support and training to minimise PHL while improving food security in Tanzania.

Keywords: Post-harvest management, Training Hermetic bags, Maize Food security, Field experiment, Randomization inference

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Egocentric Network of Local Level Institutions in Promoting Climate Resilience among Pastoral Communities in Northern Tanzania

Ronald B. Ndesanjo¹ and Mathew Senga²

Abstract

This study examined the role of local institutions in enhancing resilience to climate variability and change among pastoral communities in Northern Tanzania. Using Social Network Analysis (SNA), we established an egocentric network for investigating how different local level institutions promote or hinder pastoralists' resilience to climate variability and change impacts. Purposive sampling was used to sample representatives from local traditional leadership (institutions) for involvement in ego-network data gathering. Egocentric network data were organised in excel using the column-wise approach and used to run descriptive statistics on Stata software. The study found that the nature of institutions that work with local communities in support of climate variability and change resilience strategies include, in order of their importance: traditional leadership; village government; local NGOs; CSOs, and international NGOs. Agricultural inputs are the main form of support these institutions provide to the farmers. Overall, the study found that the level of support offered by these institutions is medium. Individually, traditional leadership emerged to offer the most support followed by the village government. Furthermore, village governments have the most ties with all the five institutions followed by local NGOs. Similarly, the most ties exist among three institutions: Traditional leadership; village governments, and local NGOs. Traditional leadership's tie with village governments is the strongest of all the ties that exist among the remaining three institutions. Ties among traditional leadership, village governments, and local NGOs emerged as complementary to building local community resilience to climate variability and change. The study, therefore, concludes that local institutions—traditional leadership, village government, and local NGOs—as well as their existing ties are instrumental in building the local community's climate resilience. Thus, policy intervention could have more impact had it been buttressed by these institutions in both their formulation and implementation as cultivating a sense of local ownership and inclusivity is paramount in the success of such endeavours at the grassroots.

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Food Security Impacts of Climate Change among Pastoral Households in Northern Tanzania

Ronald Boniphace Ndesanjo, Ida Theilade and Martin Reinhardt Nielsen

Abstract

The overall aim of the study was to investigate the impacts of climate change on food security among pastoral households in Northern Tanzania. Specific research questions included the following: What are the local climatic patterns and trends? What is the status of household food security? How does local climate influence household food security? Do households have in place food security strategies? What are the determinants of household food security sustenance? The study employed a household survey to gather primary data. Climatic data were obtained from the Tanzania Meteorological Agency (TMA). The survey was undertaken among 300 households in Simanjiro district, Northern Tanzania. Data analysis entailed multinomial regression analyses and Standardized Precipitation Index, respectively. The study found that most households did not have sufficient food supply during normal (supposedly food secure) months, thus implying low productivity and food inaccessibility. Households were found to employ concurrently both coping and adaptive strategies to address stresses and shocks and, particularly, drought-driven food insecurity. These measures include long-term (adaptive) strategies such as household food reserve and seed banking as well as short-term (coping) strategies livestock and asset selling. The study further found that the ability to buy food remains a key mechanism for households to secure their food needs, especially in times of shocks. This happens particularly during crop failure and when common coping and adaptive strategies are no longer viable. Along similar lines, the study found that livelihood diversification in the form of agro-pastoralism is a major determining factor for ensuring household food security. The strategy is commonly supplemented by selling livestock, especially when households are in a dire food scarcity situation. Thus, drought is the main driver of household food insecurity. A counter-measure could include a combination of livelihoods diversification and migration, which are a key strategy for fostering household food security and overall resilience enhancement.

Probing the Interactions of Proteins and Phenolic Compounds during Extraction of Low Viscosity Banana Juice Using FTIR Spectroscopy

Nuria Majaliwa^{1,2}, Vicent Victor¹, Clarence Mgina³, Oscar Kibazohi¹, Marie Alminger²

Abstract

The ability of East African highland bananas to produce low viscosity juice is hypothesised to be linked to interactions between proteins and phenolic compounds during the mechanical banana juice extraction. Much uncertainty, however, still surrounds the mechanism behind juice release, as some studies hypothesise the involvement of tannin, protein and polysaccharides (pectins). To evaluate the influence of proteins, polysaccharides, and phenolic compounds on juice recovery, this study analysed and compared the functional groups present in the pulp at various stages of juice extraction. Fourier transform infrared spectroscopy (FTIR) analysis was performed to provide novel information on the changes of the functional groups in the pulp structure during banana juice production using a mechanical process. Amide I, amide II regions in FTIR spectra were used to study the structural changes of proteins because of protein-polyphenol interactions. FTIR analysis displayed a reduction in phenolic compounds and a shift of protein regions (Amide I and II) during mechanical blending to extract the juice. Reduction of OH spectra intensity attributable to the interaction of hydroxyl and carbonyl groups, and the shift in the wavenumber of OH from 3300 to 2250 cm^{-1} suggest a formation of hydrogen bonding. This same phenomenon is further explained by the reduction in intensity observed at the amide I region at 1655.14 cm^{-1} . The reduced intensity in the polysaccharide's region (995.65 cm^{-1}) of the spent pulp after juice recovery could be ascribable to the interaction of polysaccharides (pectins) with other pulp components (proteins and phenolic compounds). The involvement of proteins and pectins

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with phenolic compounds were evaluated by the addition of adsorbent (bentonite) and enzyme (pectinase) during juice extraction. Since no juice was recovered, the results suggest that the chemical structures in protein and pectin were partly broken. The FTIR analysis provide novel information on the involvement of proteins, pectins, and polyphenols in juice extraction and their conformational changes following mechanical blending.

Keywords: FTIR spectroscopy, protein-pectin-polyphenol interaction, mechanical banana juice processing, banana juice.

Formulation and Characterisation of Mixed Juices from Banana, Pineapple and Passion Fruits during Storage

Victor Vicent^{1,*} and Oscar Kibazohi¹

Abstract

Juices from fresh fruits offer various health benefits, including strengthening the immune system and preventing diseases. Mixed fruit juice has a great specialty in its nutritional contents and organoleptic properties such as colour, flavour, taste, and overall appeal. This work investigated the physicochemical and sensory attributes of fruit juice of low viscosity banana juice blended with pineapple and passion juice. The juices prepared were pasteurised at 92°C for 15 s, bottled in air-tight glass bottles, and then stored at room temperature and 4°C for a month. Ascorbic acid content, total soluble solids, acidity, pH, as well as sensory evaluation were measured during the storage period. The results indicate that ascorbic acid and pH decrease significantly ($p < 0.05$) as the acidity increases. The total soluble solid was found to increase until ten days of storage. The control samples showed no changes in all physicochemical properties analysed during storage. The juice sample consisting of 80% banana juice and 20% passion juice emerged as the utmost imperative sample as it scored the highest on the hedonic scale for all the sensory attributes. The results presented in this work imply that low viscosity banana juice can serve as a major component for preparation of commercial mixed juices.

Keywords: Fruit Juice, Chemical Analysis, Sensory Evaluation, Mixed Juice Storage

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Antifungal Activity of *Artemisia Afra* against *Aspergillus Flavus* Growth and Aflatoxins Production

Noela G. Kilenga¹, Oscar Kibazohi² and Lilian D. Kaale²

Abstract

The application of medicinal plants has increasingly become pivotal in the search for an antimicrobial to control fungal growth such as *Aspergillus* spp. in food crops and feeds. The main objectives of this study are to evaluate the chemical composition and assess the antifungal activity of the essential oil and extracts of *Artemisia afra* (leaves, stem, and root barks) collected from Lushoto in Tanga region, in different seasons between July 2020 and January 2021 against *Aspergillus flavus* growth and aflatoxins production. The essential oil was extracted using steam distillation, and the extracts derived by using Soxhlet and maceration methods. The compounds and their percentage composition in the essential oil and extracts were analysed using GC-MS. The *Artemisia afra* essential oil and extracts were tested for their antifungal activity against *Aspergillus flavus* mycelial growth and aflatoxins production in Sabouraud dextrose broth (SDB) growth media. Aflatoxins production was determined by using HPLC-UV. The analysis revealed 78 compounds from *A. afra* leaves, stem and root barks across different harvesting seasons. The main compounds were borneol, hexadecanoic acid, methyl ester, α -epimuurolo, 2,4-di-*tert*-butylphenol, *p*-cymen-7-ol, β -selinene and terpinen-4-ol. The inhibitory concentration of essential oil and extracts ranged between 10-50 μ L/mL and 250-1000 μ g/mL, respectively. The antifungal activity of *Artemisia afra* essential oil was the most effective against *Aspergillus flavus* with mycelial growth inhibition of 99.97-99.99%. The extracts had mycelial growth inhibition of 22.69-62.50%. The study found that sampling from different seasons, as well as extraction methods and solvents, influenced the chemical composition which also affects the controlling of *A. flavus* mycelial growth and aflatoxins production.

Keywords: *Artemisia afra*; Essential oils; Extracts; *Aspergillus flavus*; Aflatoxins

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Black Soldier Flies and Azolla Farming as Animal Feed: A Case Study at Kaziru Poultry Farm and Research Center

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Abstract

Animal feed is a major cost in poultry farming. Sometimes the cost may be as high as 80% of the sales. The cost of protein in the feed comprises more than 55%. A common protein source for the poultry feed in Tanzania is fishmeal from Silver Cyprinid also known as Lake Victoria Sardine and *dagaa* (in KiSwahili). Due to the prohibitive cost of animal feeds, alternative low-cost sources of protein for animal feeds are essential. Kaziru Poultry Farm & Research Centre (KPFRC) was established in 2018 to produce eggs, chicks and chicken meat, but the overriding challenge was the high feeding cost, especially the protein cost. KPFRC started producing azolla, a high protein water plant in 2018, and black soldier fly larvae (BSFL) in 2020 as protein supplements. The BSFL are produced from fruit and food waste, the frass from the larvae rearing unit is used to produce azolla in water ponds and as fertiliser. Both black soldier fly larvae and azolla are fed to the chicken. Dried larvae contain 45% crude protein and 32% fat whereas dried azolla contains 20-30% protein and 10% carbohydrate. The production of larvae and azolla protein has reduced protein cost by 80% and overall feed cost by more than 50%. Egg production has increased from 65% to 75-80% of layers and the eggs yolk is more yellow than egg yolk produced chicken fed with fishmeal. Furthermore, the production of BSFL reduces carbon footprint and has a potential of reducing overfeeding.

Keywords: Poultry farming, Azolla, Black soldier Fly

Rangeland Management Practices for Enhancing Food Security in Miombo Woodlands: An Overview

Peter Rogers Ruvuga^{a, b, 1}, Ewa Wredle^a, Catherine A. Masao^b, Ismail Selmani^c, Anthony Sangeda^c, Gert Nyberg^d and Cecilia Kronqvist^a

Abstract

Miombo are unique dry woodlands in Eastern, Central and Southern Africa dominated by the *Brachystegia* tree. These woodlands are severely degraded by various human activities including livestock production. This study was undertaken in Kilosa, Tanzania to investigate the current rangeland-livestock management practices among livestock keepers in miombo. Also, it assessed the rangeland condition, forage quantity and quality variation throughout the year in miombo. The study methods comprised household interviews, focus group discussions, rangeland inventory and forage laboratory analysis. It investigated indigenous rangeland practices, vegetation cover, wood density, forage nutritional values, and aboveground biomass. The study found a lack of rangeland improvement practices among livestock keepers in miombo woodlands. Livestock-keepers attributed this lack to poor land tenure regime. Also, tree density and canopy cover were adequate within the woodlands range. Vegetation cover varied significantly throughout the year with different proportion of annual and perennial grasses. The desirable perennial grasses proportions were at the lowest during the dry months, causing an increase in undesirable plant species *i.e.* weeds. Moreover, the forage species sampled had lower nutritional values than the livestock requirement. Furthermore, indigestible contents were high during the dry months and in early rainy season. Aboveground forage biomass was estimated to be too low to sustain livestock and it significantly differed throughout the year with higher biomass following a rainfall spell. The conclusion was that the rangeland condition in Kilosa miombo woodlands was poor due to poor desirable perennial grass cover, forages of low nutritional value and changes in aboveground biomass. Thus, there is a need to introduce rangeland improvement practices such as weed control and grazing management that follow annual variation in forage species and quality in relation to livestock requirement.

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Is modern Beekeeping Commercially and Environmentally Viable? An Assessment of the Modern Adoption of Beehives in Semi-Arid Areas of Central Tanzania

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Abstract

Beekeeping is an activity that provides ecosystem services that ensure the growth of natural vegetation in addition to supporting the livelihoods of rural poor people by providing them with income and food security generated from honey and beeswax business. This study assessed the modern beehives' adoption and its implications for livelihoods and forest conservation in Chemba district, Dodoma region. The research results indicate that 37.9% of the modern beekeepers obtain an average income of above 50,000Tshs (21.57 USD) per annum whereas 36% of the traditional beekeepers obtain less than 50,000Tshs (21.57 USD) every year from using local beehives that were found to be environmentally-unfriendly. Therefore, the study recommends that the government in collaboration with private stakeholders, should plan to improve the beekeeping technology by supporting and providing necessary services such as extension services, and access to financial resources. These measures could accelerate the adoption of modern beekeeping technology and ensure sustainable livelihood and forest conservation in the region.

Keywords: Tanzania, Beekeeping, Chemba, Beehives, Forest Conservation

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Beekeeping as a Tool for Environmental Conservation in Semi-Arid Areas of Central Tanzania

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Abstract

This study explored the contribution of beekeeping as a tool for environmental conservation in semi-arid areas of Central Tanzania, specifically in Singida region. Data collection methods were Household Interviews, Key Informant Interviews, Focus Group Discussions, Vegetation surveys and field observations. The findings show that 73.3% of the beekeepers considered income generation as the primary factor for engaging in beekeeping than environmental conservation. The results from Relative Importance Index (RI) a high value as beekeeping encouraged the planting trees, hence leading to conservation (0.892); beekeeping succeeded in preventing tree cutting (0.881); and there is more vegetation cover and varieties in apiaries (0.906), which reveals that beekeeping conserves the environment. Furthermore, biodiversity did not vary significantly between apiary and non-apiary areas whereby trees species diversity index was 1.415 and 1.075 in the first location, and 0.600 and 1.631 in the second location. Diversity of shrubs was 1.619 and 1.702 in the first location, and 2.429 and 1.599 in the second location. Also, 59.7% of the beekeepers reported using firebrands for generating smoke during honey harvesting that caused minimal effect on the ecosystem by causing death of the bees than causing bushfires. The study, therefore, recommends that beekeeping in the study area be strongly considered as a tool for environmental conservation while generating ecosystem goods and services for the community.

Keywords: Beekeeping, Apiary, Pollination, Environmental Conservation

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Spatial Prediction of Irish Potato Suitable Soils from Topographic Attributes Derived from a Digital Elevation Model

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Abstract

This study predicted Irish potato suitable soils from DEM-derived topographic attributes in Mavumo area, West Usambara Mountains, Tanzania. It studied spatial distribution of topographic features and soils of the study area and spatial relationship between Irish potato suitable soils and DEM-derived topographic attributes. The study employed Remote Sensing and GIS techniques coupled with standard field survey and literature review methods to collect data on the landscape features and soils of the study area covering 3.68 square kms. Data analysis using ArcGIS 10.4 and R software package was done using data obtained from digital elevation model (DEM), field survey and laboratory analysis. The performance of this prediction was assessed by comparing its values with those from a GIS-based Irish potato soil suitability map created using the ArcGIS 10.4 software. The findings on the spatial distribution of topographic features and soils of the study area indicate that upper slopes, mid slopes and lower slopes of high-altitude plateau, upper slopes and mid slopes of low altitude plateau and plateau valley bottoms are topographic features of the study area. Also, the study identified seven (7) dominant soil types, namely Fluvisols, Alisols, Luvisols, Lixisols, Vertisols, Leptosols and Regosols. Findings from correlation analysis indicate that topographic attributes that showed significant correlation with Irish potato suitable soils (at $p < 0.01$) are only elevation ($r = -0.726$), slope ($r = -0.685$) and aspect ($r = -0.452$) out of 31 topographic attributes derived from DEM. Further findings on regression analysis between Irish potato suitable soils and topographic attributes showed that 65.9% of the spatial variation in Irish potato suitable soils can be explained by topographic attributes (i.e., slope, elevation and aspect). The study, therefore, recommends bench terracing in the area as the means for reducing slope and elevation effect. In addition, the applicability of the model developed for crop suitability analysis suggests the need to use additional data such as geology, land use, drainage and vegetation

to improve reliability the model prediction.

Keywords: Spatial prediction; Irish potato; soil; Digital Elevation Model; GIS

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Phylogenetic Diversity of Actinomycetes from Momela Soda Lakes, Arusha National Park, Tanzania

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Abstract

Momela Soda Lakes consist of seven small lakes that are hypersaline alkaline situated in part of the East African Rift Valley found in Arusha National Park, Tanzania. The lakes are fed by separate underground water sources with slightly varying mineral content resulting in colour variation and supporting distinct kinds of growth. In this study, the diversity of actinomycetes in surface water and sediments of five lakes were investigated using culture-dependent and culture-independent molecular techniques. In all, 34 out of 112 and 13 out of 85 representatives of actinomycetes isolates and clones, respectively, were selected using the CD-HIT program. Analysis of their 16S rRNA gene sequences displayed the presence of species affiliated to 15 different genera, namely *Mycobacterium*, *Rhodococcus*, *Microbacterium*, *Isoptericola*, *Dietzia*, *Leucobacter*, *Jonesia*, *Nesterenkonia*, *Micrococcus*, *Streptomyces*, *Hoyosella*, *Norcardiopsis*, *Cellulomonas*, *Bogoriella* and *Agromyces*. The results show 5 and 12 putative new actinomycetes isolates and clones, respectively. This is the very first report of isolation of genera *Mycobacterium* and *Hoyosella* from a soda lake globally as well as the genera *Isoptericola*, *Jonesia*, *Micrococcus*, *Leucobacter* and *Agromyces* from a soda lake in East Africa. Since actinomycetes are known as potential sources of biotechnologically important compounds, the species have set a platform for searching for novel bioactive compounds.

Keywords: Actinomycetes, Extreme environment, Momela Soda Lakes, Phylogenetic Diversity, Tanzania

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Sub-Theme 5: Molecular Bioscience

Structural Characterisation of a Novel Cysteine-Rich Peptide from the Massive Edible Mushroom *Kusaghiporia Usambarensis*

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Abstract

Cysteine-rich peptides are produced by organisms in all kingdoms of life. They possess a wide-range of structural and functional features, which makes them attractive for drug development. *Kusaghiporia usambarensis* is well-known in traditional medicine for its health benefits role. However, the active ingredient(s) displaying these health benefits remains indeterminate. Here, we report the isolation and structural characterisation of a novel cysteine-rich peptide, *kusaghitide*, from the gigantic mushroom *K. usambarensis*. The mature peptide is 54 amino acid residues long and contains three disulfide bonds. The nuclear magnetic resonance spectroscopy structure revealed that peptide fold into a five anti-parallel beta strands with cysteine-cysteine pairs between I-III, II-V, and IV-VI. A structural search reveals that this is a novel feature not seen before and constitutes a unique fold with no known homologs found in Protein Data Bank as indicated via a DALI server search. The function of the *kusaghitide* is unclear and this structural characterisation, thus paving the way for future search of its biological role.

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Calicioid Lichens; Revision of Coniocybe Ach.

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Abstract

Coniocybe Ach., a genus of the calicioid lichens, was revised based on molecular studies and morphological features. The genus was found to be distinct from other species of *Chaenotheca* s. lat. A total of 51 new sequences (13 ITS, 24 nuLSU and 14 RPB1) for *Chaenotheca* s. lat. were produced. Phylogenetic analyses using three markers (ITS, nuLSU and RPB1) showed *Coniocybe* to form a monophyletic clade in *Chaenotheca* s. lat. *Coniocybe* was emended and found to include, apart for its type *C. furfuracea*, also *C. brachypoda* and *C. confusa* along with a newly-described species, *C. eufuracea*.

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Antimicrobial Activities of Endophytic Fungal Crude Extracts Isolated from Cashew Tree (*Anacardium occidentale*)

Nana Amiri¹ and Donatha D Tibuhwa²

Abstract

This study presents the antimicrobial activities of endophytic fungal crude extracts isolated from leaves, stems and roots of cashew trees (*Anacardium occidentale*), which exhibited disease symptoms and those resistant from Fusarium wilt in Mtwara region. Sections of the cashew trees were made and cultured to isolate endophytes. Eight endophytes were isolated and characterised by using morphological and molecular markers. *Neopestalotiopsis*, *Penicillium*, *Lasidiopodia* and *Daldinia* sp isolated from resistant trees and *Auxarthron* and *Aspergillus* sp from diseased trees. Antimicrobial activities of the isolated endophytic fungal crude extracts were done against pathogenic *Fusarium oxysporum* and three human pathogens namely, *Staphylococcus aureus*, *Escherichia coli*, and *Candida tropicalis*. Results showed that all the endophytic fungal crude extracts isolated from resistant plants and one from diseased plants exhibited positive antimicrobial activities against bacteria and fungus *Candida tropicalis* but they had no antifungal activity against *Fusarium oxysporum*. This study could contribute to the discovery and innovation of therapeutics. This study also suggests that the resistance to Fusarium wilt disease might be caused by other unknown factors. More research work, therefore, is recommended for establishing other factors including endophytic bacteria, biotic and abiotic factors that could contribute to the resistance of cashew plants to *Fusarium oxysporum*.

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Molecular Diversity of Hard Tick Species from Selected Areas of a Wildlife-Livestock Interface in Mikumi National Park, Morogoro Region, Tanzania

Donath Damian¹, Modester Damas¹, Jonas Johansson Wensman² and Mikael Berg³

Abstract

Ticks are one of the most important arthropod vectors and reservoirs as they harbour a wide variety of viruses, bacteria, fungi, protozoa, and nematodes, which can cause diseases in human and livestock. Due to their impact on the health of humans, livestock, and wild animals, increased knowledge of ticks is essential. So far, the published data on the molecular diversity between hard ticks species collected in Tanzania is non-existing. The objective of this study was, therefore, to determine the genetic diversity between hard tick species collected in the wildlife-livestock interface ecosystem of Mikumi National Park in Tanzania using the mitochondrion 16S rRNA gene sequences. Adult ticks were collected from cattle (632 ticks), goats (187 ticks), and the environment (28 ticks) in the wards bordering Mikumi National Park. Morphological identification of ticks was performed to a genus level. To identify ticks to species level, molecular analysis based on mitochondrion 16S rRNA gene was performed. Ticks representing the two genera (*Hyalomma* and *Rhipicephalus*) were identified using morphological characters. Six species were confirmed based on mitochondrion 16S rRNA gene, including *Rhipicephalus microplus*, *Rhipicephalus evertsi*, *Hyalomma rufipes*, *Hyalomma truncatum*, *Hyalomma marginatum*, and *Hhyalomma turanicum*. The different clusters of tick species reflects the possible biological diversity of the hard ticks present in the study region. Further studies are, however, required to quantify species of hard ticks present in the study region and the country over a larger scale.

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Genetic Relationship between Hard Ticks (Ixodidae) Infesting Cattle in a Wildlife-Livestock Interface in Mikumi National Park, Tanzania

Donath Damian¹, Modester Damas¹, Jonas Johansson Wensman² and Mikael Berg³

Abstract

There has recently been a substantial increase in the number of tick species and tick-borne infectious agents in Tanzania. Owing to their impact on human, livestock, and wild animal health, increased knowledge on ticks is pivotal. So far, no published data on the genetic relationship between hard tick (*Ixodidae*) sequences collected from cattle are available in Tanzania. The genetic relationship utilises the evidence of evolutionary relationship and evolutionary divergence of species to determine the genetic variation within and between species. Ticks from cattle in the wards, which border Mikumi National Park, were collected in the dry season, November to December 2019. Evolutionary relationships and genetic distances between ticks were determined using Maximum likelihood and Kimura 2-parameter methods, respectively. The Maximum Likelihood tree from mitochondrion 16S rRNA gene sequences derived from *Rhipicephallinae* and *Hyalomminae* subfamilies generated five (clusters) phylogroups (A–E). Group A constitutes the *Rhipicephalus* genus with two monophyletic groups, *R. microplus* and *R. evertsi*. Group B members included *H. truncatum*, group C contain *H. rufipes*, group D comprised *H. turanicum*, and group E included *H. marginatum*. In the genetic variation analysis, it was observed that, *Hyalomma marginatum* recorded the highest mean and pairwise intraspecies distance value whereas the highest pairwise intra-genus value was recorded in *Hyalomma* genus. Notably, high values of 0.11 and 0.23 mean and pairwise genetic distances, respectively, in the tick community were recorded. The five phylogroups and high genetic distance values observed in this study reflects possible biological diversity of hard ticks present in the study area. Considering the value of the cattle in the livelihoods and economies of people and the country, the outcomes of this study will be useful in planning integrated control strategies for ticks and tick-borne diseases in Tanzania.

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Diversity of Viruses in Hard Ticks (Ixodidae) in a Wildlife-livestock Interface Ecosystem in Mikumi National Park, Tanzania

Donath Damian¹, Modester Damas¹, Jonas Johansson Wensman² and Mikael Berg³

Abstract

Many of the recent emerging infectious diseases have occurred due to the transmission of the viruses that have wildlife reservoirs. Arthropods, such as ticks, are known to be important vectors for spreading viruses and other pathogens from wildlife to domestic animals and, eventually, humans. In the present study, we explored the diversity of viruses in hard ticks (Ixodidae) from selected areas of a wildlife-livestock interface ecosystem in the Mikumi National Park, Tanzania using a metagenomic approach. cDNA and DNA were amplified with random amplification and Illumina high-throughput sequencing was performed. The high-throughput sequenced data was imported to the CLC genomic workbench and trimmed based on quality ($Q = 20$) and length (≥ 50). The trimmed reads were assembled and annotated through Blastx using Diamond against the National Centre for Biotechnology Information non-redundant database and its viral database. The MEGAN Community was used to analyse and compare the taxonomy of the viral community. The contigs and singletons obtained were further subjected to alignment and mapping against reference sequences. The viral sequences identified in the study region were classified into bacteria, vertebrates, protozoa, and invertebrates viruses. Viral groups related to known viral families—*Retroviridae*, *Flaviviridae*, *Rhabdoviridae*, *Chuviridae*, *Orthomyxoviridae*, *Phenuiviridae*, *Totiviridae*, *Rhabdoviridae*, *Parvoviridae*, *Caulimoviridae*, *Mimiviridae*—as well as unknown viral families were reported. This result indicates that there are many viruses present in the study region, which we are not aware of and do not know the role they have or if they have the potential to spread to other species and cause diseases. Therefore, further studies are required to delineate the viral community present in the region over a large-scale.

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Characterisation and Analysis of Antimicrobial Activity of Endophytic Fungi Associated with Medicinal Plants from Selected Regions of Tanzania

Zuhura Mwangi¹, Esther Mvungi² and Donatha Tibuhwa¹

Abstract

This study characterised and analysed antimicrobial activities of endophytic fungi associated with 10 medicinal plants from three regions of Tanzania: Dar es Salaam, Tanga, and Kilimanjaro. Using 23 endophytic fungi isolates from different parts of medicinal plants obtained after disinfection, the study performed different biological tests. The ethyl acetate crude extracts of endophytic fungi secondary metabolites were screened for antimicrobial activities against Gram-negative bacteria (*Basillus substilis* and *Staphylococcus aureus*), Gram-positive (*Escherichia coli*) and fungi pathogen (*Candida albicans*). The results revealed that endophytic fungi from 9 medicinal plants exhibited antimicrobial activity against the tested pathogenic bacteria and fungi. Of all the isolates studied, crude extract secondary metabolites of endophytic fungi from *Ocimum suave* leaf and *Alium sativum* clove exhibited strong antimicrobial activity with minimum inhibition (MIC) ranging from 0.125 mg/ml to 0.5 mg/ml against all the pathogenic bacteria and fungi tested. On the other hand, the isolated endophytes were found to belong in 9 genera *Colletotrichum* being dominant and found in all plants. The results further revealed that diversity of endophytic fungi varied irrespective of the geographical location of the host plants while the phytochemical analysis of their secondary metabolites revealed the presence of vital constituents potential for medicinal applications namely; alkaloids, phenols, flavonoids, tannins, terpenoids, tennins, steroids, amino acids, carbohydrates and saponins. This study demonstrated that secondary metabolites of endophytic fungi from the studied medicinal plants possess important phytochemical and exhibit antimicrobial potential against the tested human pathogens, which could contribute to endeavours aiming for new therapeutic inventions.

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Anti-Respiratory Syncytial Virus Activity *Erythrina* *Abyssinica* Stem Bark Extracts

Mollel JT^{1,2}, Said J², Masalu RJ¹, Bergstrom T², Trybala E²

Abstract

According to WHO, about four billion people (about 80% of the world's population) in developing countries rely on medicinal plants products for their primary healthcare needs. Ethnomedicine provides a rich source of information crucial for investigating medicinal plants. The present study investigated antiviral activity of *Erythrina abyssinica* DC stem bark extracts from Kagera region, Tanzania, selected based on an ethnobotanical survey. Crude extracts were obtained by sequential extraction using n-hexane, ethyl acetate and water successively. Water extracts were further purified by ethanol precipitation. Anti-RSV activity was determined using plaque reduction assay on monolayer cultures of human laryngeal epidermoid carcinoma (HEp-2) cells. Tetrazolium-based (MTS) assay was used to assess cytotoxicity, anti-RSV potency of active extracts was determined using yield-reduction assays. The mode of anti-RSV activity was studied with the help of time-of-addition and virucidal assays. Water extracts—but not ethyl acetate and n-hexane extracts—demonstrated promising anti-RSV activity, 50% inhibitory concentration (IC_{50}) selectivity indices (SI: CC_{50}/IC_{50}), 14.5 $\mu\text{g/ml}$ and $SI > 344.8$, respectively. Purification by ethanol precipitation increased the activity IC_{50} 2.1 $\mu\text{g/ml}$ and $SI > 476.2$. Results from RSV yield-reduction assay demonstrated a potent anti-RSV activity as depicted by the decrease in viral production by 1.8 \log_{10} (P value < 0.05) and 1.5 \log_{10} (P value < 0.05) both extracellular and cell-associated respectively. Ethanolic precipitates also suppressed viral production by 1.4 \log_{10} (P value < 0.05) and 1.4 \log_{10} (P value < 0.05) both extracellular and cell associated respectively. With time-of-addition assay results, a high anti-RSV effect was observed when water extracts/ethanolic precipitates were added prior to or during the virus cell attachment contrary to post-attachment stage, an implication of the virucidal mode of action. Virucidal assay results verified the virucidal mode of action whereby, active extracts/ethanolic precipitates irreversibly inactivated the infectivity of the viral particles. Overall, extracts from *E. abyssinica* exhibit

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a potent anti-RSV activity, which is specific and selective to the virus. The observation that only water extracts exhibited anti-RSV activity might suggest that polar compounds were responsible for the bio-activity observed.

Anti-Respiratory Syncytial Virus Activity of *Anthocleista Grandiflora* Extracts

Molle JT^{1,2}, Said J², Masalu RJ¹, Bergstrom T², Trybala E²

Abstract

Syncytial virus (RSV) is a significant cause of respiratory infections in infants and elderly. In fact, it is one of the leading causes of mortality in under one-year-old infants globally. Despite such a huge public health burden, there is no effective treatment for RSV. In this study, anti-RSV activity of *Anthocleista grandiflora* Gilg stem bark was investigated. The plant was collected from Kagera region, Tanzania, with the selection based on an ethnobotanical survey. Using Sequential extraction, the study obtained crude extracts using n-hexane, ethyl acetate and water successively. Crude water extracts were further purified by ethanol precipitation. Plaque reduction assays were used to establish anti-RSV activity on a monolayer cultures of human laryngeal epidermoid carcinoma (HEp-2) cells. To understand cytotoxicity tetrazolium-based MTS colorimetric assay was performed on HEp-2 cells. Further antiviral potency assessment was performed using yield-reduction assay whereas time-of-addition- and virucidal-assays were conducted to understand the mode of action. *A grandiflora* stem bark water but neither n-hexane nor ethyl acetate extracts demonstrated a promising anti-RSV activity, IC₅₀ 17µg/ml substantial selectivity indices (SI: CC₅₀/IC₅₀) = 194.1. Further purification extracts by ethanol precipitation increased the activity IC₅₀=2.9µg/ml (SI >344.8). Yield-reduction assay revealed a potent anti-RSV activity as evidenced by a reduction in viral production in both extracellular and cell associated by 2.1 log₁₀ (P value <0.005) and 1.6 log₁₀ (P value <0.005), respectively. Ethanolic precipitates also suppressed the production of RSV progeny by 1.5 log (P value <0.05) and 1.0 log (P value <0.05) in extracellular and cell associated, respectively. Time-of-addition assay results hinted at the virucidal mode of antiviral activity; high anti-RSV effect was observed when crude water extracts/ethanolic precipitates were added prior to or during the virus-cell attachment contrary to post-attachment stages. The results from virucidal assay were consistent with the findings

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from time-of-addition, an indication of the virucidal mode of action, of which crude water extracts and their ethanolic precipitates irreversibly inactivated the infectivity of the viral particles. Conclusively, water extracts and their ethanolic precipitates from *A. grandiflora* possessed anti-RSV activity. Precisely, the antiviral activity is viral-specific and targeted the virus particle.

Why has Permanent Control of Cassava Brown Streak Disease in Sub-Saharan Africa Remained a Dream since the 1930s?

Herieth Rhodes Meroa¹, * Sylvester Leonard Lyantagaye^b,
and Erik Bongcam Rudloff^c

Abstract

Effective control of ipomoviruses that cause cassava brown streak disease (CBSD) in Africa has remained problematic despite eight decades (1930–2021) of research efforts to contain it. Molecular mechanisms underlying resistance breakdown in genetically improved cassava are still unknown. The vast genetic diversity of cassava brown streak viruses, which is crucial for the improvement of routine reverse transcription polymerase chain reaction (RT-qPCR) assays in CBSD-endemic regions of Africa, is controversial and underrepresented. From a molecular epidemiology viewpoint, this review discusses why permanent control of CBSD is difficult in the modern era, even with the presence of diverse *in silico* and omics tools, recombinant DNA, and high throughput next-generation sequencing technologies. Following an extensive nucleotide data search in the National Centre for Biotechnology Information (NCBI) database and a literature review in PubMed and Scopus, we report that genomic data of 87.62% (474/541) strains of cassava brown streak virus are missing due to poor sequencing capacity in Africa. In fact, the evolution dynamics of viral virulence and pathogenicity has yet to be fully explored from the 67 (12.38%) genomic sequences available, owing to poor bioinformatics capacity. Tanzania and Zambia have the highest and lowest disease inoculum pressure, correspondingly. Knowledge gaps in molecular biology and the overall molecular pathogenesis of CBSD viruses impede effective disease control in Africa. Recommendations for viable solutions to the research questions, controversies, and hypotheses raised in this study serve as a roadmap for the invention of more effective CBSD control methods.

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Cassava Brown Streak Viruses Express Second 6-kilodalton (6K2) Protein with Varied Polarity and Three Dimensional (3D) Structures: Basis for Trait Discrepancy between the Virus Species

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and Erik Bongcam Rudloff^c

Abstract

Cassava Brown Streak Virus (CBSV) is hard to breed resistance for compared to Ugandan Cassava Brown Streak Virus (UCBSV) species, despite both causing the most catastrophic Brown Streak Disease of Cassava (CBSD) in Africa. Reasons behind CBSV species accumulating in cassava tissue at higher titers and replicate its genomic RNA more rapidly than UCBSV species are not clearly understood. The present in silico study was conducted to understand molecular basis for the trait discrepancy between CBSV and UCBSV species, from structural biology viewpoint. Ab initio modelling of three-dimensional (3D) structures of the second 6-kilodalton (6K2) protein using ROBETTA server revealed that (95% and 5%) and (85% and 15%) strains of 20 CBSV and 20 UCBSV species, respectively, expressed the protein in homo-trimeric and homo-tetrameric forms, correspondingly. Molecular Phylogenetic analysis of 6K2 by using Maximum Likelihood estimation method in UGENE version 38.1, revealed CBSV and UCBSV species share common ancestral origin with evident (N↔S, R↔K, S↔P, L↔I, L↔V, I↔V, M↔L, L↔A, S↔A, and L↔S, A↔T, E↔S, E↔N, E↔D, N↔D) S↔V, S↔I and E↔G) substitution mutations between them. By Protein Parameters tool, 95% and 85% of the strain population of CBSV and UCBSV species studied were, correspondingly, determined to express hydrophilic and hydrophobic 6K2, respectively. This trait favours faster systemic spread of the former through vascular tissues of cassava than in the latter. Therefore, we hypothesise that, the hydrophilic 6K2 gives CBSV species interaction advantage with Nuclear

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Inclusion b protease domain (NIb) and Viral genome-linked protein (VPg), components of Virus Replication Complex (VRC) than the hydrophobic 6K2 expressed by UCBSV species. Experimental studies are necessary to resolve 3D structures of 6K2, VPg and NIb and comprehend the complex molecular interactions between them. Targeting 6K2 protein for improvement of RNA interference (RNAi)-directed transgenes of virus-resistant Cassava, will reduce CBSD-epidemics, food insecurity and poverty in Africa.

Metagenomics Reveals a Micro-community of Biotechnologically Potential Halophiles from the Big Momela Microbiome

Reuben Maghembe^{1,2,6}, Stephen Nyandoro³, Sylvester Leonard Lyantagaye,⁴Ajith Kumar⁵, Souvik Kusari^{6*}, Rajni Hatti-Kaul^{7*}

Abstract

The Momela ecosystem comprises seven lakes with unstudied microbiome. Though the biodiversity in rest of the Momela lakes remain largely untapped, the Big Momela biodiversity has been considerably studied albeit with conventional microscopic and simple molecular methods. In this work, metagenomics, which is part of the state-of-the-art approaches, was applied. DNA samples obtained on two occasions were sequenced with Illumina Novaseq. Bioinformatics analysis revealed a diversity of microbial species, predominated by the phyla Actinobacteria, Proteobacteria and Cyanobacteria. At the genus level, *Nocardiopsis*, *Planctomyces*, *Arthrospira*, and *Rhodospirellula* were the most abundant in the first cohort. In the second cohort, *Arthrospira*, *Chlorella*, *Micromonas*, *Halomonas*, and *Ostreococcus* were the most abundant. A draft genome of *Nocardiopsis* was generated, and analysis of its structurally-annotated genome with the antiSMASH database revealed remarkable gene clusters involved in the biosynthesis of important secondary metabolites in the polyketide synthase as well as the nonribosomal peptide synthetase pathways. On the other hand, a nearly full genome of *Halomonas* sp was recovered from the second cohort, whose analysis revealed genomic features of common *Halomonas* species, with biotechnological importance. This study, being the first to deploy whole metagenome sequencing in the East African Rift Valley, highlights the importance of Big Momela Lake as a reservoir of an ecologically and biotechnologically diverse microbiome, with industrially important species. The study also contributes to the understanding of a novel *Halomonas* species and of other strains at the genomic level.

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Antimicrobial Activities of *Tephrosia Vogellii* against Selected Pathogenic Fungi and Bacteria Strains

Stephano Hanolo Mlozi^{1,b}, Juma A. Mmongoyo^b and Musa Chacha^a

Abstract

Candida albicans and *Cryptococcus neoformans* are dangerous pathogens causing fungal diseases. *C. albicans* and *C. neoformans* developed resistance to fungicides such as fluconazole. Similarly, pathogenic bacteria *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae* and *Salmonella typhi* have become resistant to antibiotics such as methicillin. Thus, searching for alternative antimicrobial agents is inevitable and essential. *Tephrosia vogellii* used traditionally for managing fungal and bacterial diseases is a potential source of antimicrobial agents. It is in this vein that, antimicrobial activities of leaf and root extracts of *T. vogellii* were evaluated against *C. albicans* (ATCC 90028), *C. neoformans* (clinical isolate), *S. aureus* (ATCC25923), *E. coli* (ATCC29953), *K. pneumoniae* (ATCC700603) and *S. typhi* (NCTC8385). A two-fold serial dilution method using the sterilised 96 wells of polystyrene microtitre plates was applied to determine the minimum inhibitory concentration (MIC) of extracts. Hexane and dichloromethane extracts exhibited the lowest activity against fungi strains with MICs >10 mg/mL. Root and leaf methanolic extracts exhibited activity at MICs of 5 and 1.25 mg/mL, respectively, against both tested fungi. Dichloromethane and methanolic extracts exhibited antibacterial activity with MICs ranging from 2.5 - 10 mg/mL and 0.625 - 5 mg/mL, respectively. Antimicrobial activities of the extracts of *T. vogellii* revealed the potentiality of bioactives against fungal and bacterial diseases.

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Determination of Maternal Vaginal Microbial Community Composition during Pregnancy and Its Association with Preterm Birth in Tanzania

Rugumisa BT, Sangeda RZ, Massawe NS, Lyantagaye SL, Bongcam-Rudloff E

Abstract

Preterm birth is the leading cause of mortality in under-five children, accounts as it does for 50% of the global neonatal deaths. Vaginal microbiota is associated with the risk of PB but this association is population-dependent. The objective of this study was to characterise the vaginal microbiota during the third-trimester of pregnancy and determine microbial taxa that are associated with spontaneous preterm birth in Tanzania. A nested case-control study that involved 254 women receiving antenatal care and, subsequently, giving birth spontaneously to live singletons at MNH was conducted. From the cohort there were 36 cases of spontaneous preterm birth to singletons. Controls were selected through simple random selection of women who delivered them. Vaginal swabs were collected and microbial DNA was extracted from the swabs. Vaginal microbiota was analysed through sequencing of the 16S rRNA gene using Illumina MiSeq platform and universal primers (341F-CCTACGGGNGGCWGCAG and 785R-GACTACHVGGGTATCTAATCC) targeting the V3 and V4 regions. Bioinformatics analysis of the sequences was performed using QIIME pipeline and Calypso software. *Faecalibacterium*, *Gemmiger*, *Roseburia*, *Ruminococcus* and *Oscillospira* genera were associated with an increased risk of preterm birth whereas *Lactobacillus* was associated with a reduced risk of preterm birth. The genus *Ruminococcus* has never been found in any other population and was found to be unique to Tanzania. This work is the first presentation of the vaginal microbiota of pregnant women in Tanzania and its association with preterm birth. The findings may facilitate the development of microbial markers and microbial-based treatments for diagnosis, prevention, and treatment of preterm births.

Factors Associated with Risk of Preterm Delivery in Tanzania: A Case-control Study at Muhimbili National Hospital (MNH).

Rugumisa BT, Bongcam-Rudloff E, Lukumay MS, and
Lyantagaye SL

Abstract

To determine factors associated with the risk of preterm delivery among expectant women delivering at the Muhimbili National Hospital (MNH) in Tanzania. A 1:1 case-control study was conducted to assess maternal socio-demographic, lifestyle and current and previous obstetric factors associated with the risk of preterm delivery. Mothers of preterm infants were treated as cases and those of term infants served as controls. Chi-square test and logistic regression were used to assess the association between the factors and risk of preterm delivery. Out of 468 women, 444 were eligible for the study (cases: n=222; controls: n=222). Maternal type of employment ($P=0.039$), previous preterm delivery ($P=0.002$), previous spontaneous abortion ($P=0.004$), uterine scar ($P<0.001$), parity ($P=0.034$), number of antenatal care visits ($P=0.032$), PROM ($P<0.001$), placenta previa $P=0.002$), bleeding during second trimester ($P=0.004$), pre-eclampsia ($P<0.001$) and maternal anemia ($P=0.033$) were associated with the preterm delivery risk. The main risk factors associated with preterm delivery included previous preterm delivery (OR=13.23, 95% CI: 1.72-101.95), placenta previa (OR=12.63, 95% CI: 1.63-97.98) and PROM (OR=8.77, 95% CI: 1.33-4.60). Close monitoring of pregnant women, who exhibit any of these risk factors, is important in preventing or reducing the risk of preterm delivery in Tanzania.

**Sub-Theme 6:
Applied Marine Sciences for
Sustainable Fisheries and
Aquaculture**

Common Garden Comparison of Native Nile Tilapia (*Oreochromis niloticus*) Strains Cultured in Brackish and Freshwater Environments

Redempta A Kajungiro^{1,2}, Christos Palaiokostas¹, Anna N Haldén³, Chacha Mwita², Matern SP Mtolera⁴ and Dirk Jan de Koning¹

Abstract

This study was designed to evaluate the growth performance of six native Nile tilapia, *Oreochromis niloticus* strains (TAFIRI, FETA, Karanga, Igunga, Ruhila and Victoria) in Tanzania. A common garden experiment was carried out for three months on 1,260 fish cultured in either freshwater or brackish water (2-5 ppt) environments. Traits recorded for growth performance were body weight, total length, standard length, body depth and perimeter. The effect of strain, environment and pond were highly significant for all the traits tested ($P < 0.001$). Meanwhile, post-hatch age was only significant for total length and standard length ($P < 0.05$). In the case of brackish water rearing, the Igunga strain had the fastest growth rate and the Victoria one was the lowest performing strain. On the other hand, in the case of the freshwater trial the best performing strain was Karanga whereas TAFIRI had the lowest performance. Furthermore, the strain by location interaction was statistically significant ($P < 0.001$). The mortality rate was higher (42%) for strains cultured in brackish water than those reared in freshwater (9%). In both environments, all the performance traits significantly ($P < 0.001$) and positively correlated. Overall, the growth performance of Nile tilapia strains was lower in freshwater than in brackish water environments. Our results demonstrate that there are differences in growth performance among the Nile tilapia strains tested and that the strains ranked differently for growth-related traits between the two environments. Therefore, a base population for the future breeding programme should be formed from the best performing strains in both environments tested.

Key words: Common garden, Strain, Growth performance, Brackish environment, Freshwater environment

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Biomass and Nutritive Value of Spirulina (*Arthrospira fusiformis*) Cultivated in a Cost-Effective Medium

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Charles Venance Lugomela^{3,4}

Abstract

Cultivation of spirulina at commercial scales relies on analytical grade-based media, which are expensive and so are the products. This study assessed the biomass, proximate composition, and other useful compounds in Spirulina (*Arthrospira fusiformis*) produced using a cost-effective culture medium (LCMA), and the results were compared with those from a standard Zarrouk medium grown spirulina. The LCMA medium was formulated using a commercial NPK10-20-20 fertiliser as a source of the three major nutrients for spirulina growth, and other three ingredients from Zarrouk medium. The experiment was conducted for 28 days in the glass aquaria under indoor conditions. Standard analytical methods were applied for the determination of proximate composition, chlorophyll, minerals, and vitamins in the spirulina biomass. The LCMA medium showed the best growth conditions by accumulating higher chlorophyll content ($0.99 \pm 0.02\%$) and dry weight (0.75 ± 0.01 g/100 ml) as well as attaining higher optical density (2.06 at day 15) earlier than the Zarrouk medium. The results of the proximate analysis for spirulina cultured in the LCMA medium were of decent quality, with the protein contributing more than 50% of its dry matter. It was further observed that the LCMA was an ideal medium for the optimisation of vitamins and some minerals since it recorded a significant amount of most of the vitamins analysed together with the minerals sodium and potassium compared with the Zarrouk medium. Based on the findings, the study suggested that LCMA medium could serve as an alternative and cheap medium for maximisation of biomass and production of useful biochemical compounds in spirulina species.

Keywords: Spirulina. *Arthrospira fusiformis*. Biomass production.
Biochemical composition. NPK10-20-20 fertiliser. LCMA medium

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Comparison of Seaweed Growth, Fish Abundance and Diversity in Deep Water Floating Raft with Tubular Nets and Shallow Water Off-bottom Lines Seaweed Farms

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Abstract

This study compared the growth performance of *Eucheuma denticulatum*, fish abundance, and diversity between deep water (using tubular nets) and shallow water (off-bottom) seaweed farming methods. For each farming method, three plots were set and fish abundance, diversity and seaweed growth rates were measured at intervals of 15 days. Belt transects measuring 10 m x 4 m each, were established on seaweed farms for fish observations. Fish were identified to the lowest possible taxonomic level by underwater census. The results show that the growth rate of *E.denticulatum* in deep water farms was slightly higher at an average daily growth rate (DGR) of $3.42 \pm 0.18\% \text{ day}^{-1}$ compared with $3.01 \pm 0.27\% \text{ day}^{-1}$ for shallow water farms but with no significant differences ($p = 0.079$) likely due to higher herbivory in the deep-water farms. Fish abundance and diversity were higher in deep water farms but insignificant ($t_{(34)} = 0.69$, $p = 0.49$ and $t_{(34)} = 0.424$, $p = 0.67$, respectively). Habitat complexity and seaweed growth rate were almost similar for both farming methods, hence attracting comparable numbers of fish. Further studies are recommended on fish community structures, differences between the two farming methods and effects of herbivory.

Keywords: *E. denticulatum*; seaweed farming methods; growth; fish diversity and abundance.

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Detection and Characterisation of *Pseudomonas* Species in Cultured Tilapia (*Oreochromis Niloticus*) in Pwani Region, Tanzania

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Matern S. Mtolera¹

Abstract

This study was carried out to detect and characterise *Pseudomonas* species in cultured Nile tilapia in Pwani (Coast), Tanzania. In all, 150 health and diseased cultured Nile tilapia were randomly sampled from fishponds in Bagamoyo, Kibaha and Mkuranga districts between April and July 2020. The gills, liver and kidney were sampled for bacteria isolation. Isolated bacteria were identified by microscope (Gram stain), biochemical test, and further by molecular tools. Sequencing of 16S rRNA and phylogenetic analysis revealed 8 isolates belonging to *P. aeruginosa*, *P. fluorescens* and *Pseudomonas* sp. with the significant similarity of 95 - 100%. The prevalence of infection with *Pseudomonas* species among the fish examined was 5.3%. Also, the farmers' knowledge and ponds management practices were assessed. It was observed that there was lack of biosecurity practices and fish health management measures at the farm level. Most of the fish farmers lacked proper awareness and knowledge on fish diseases and causative agents. Therefore, this study suggests that the presence of *Pseudomonas* species in the Nile tilapia sampled was associated with lack of biosecurity practices, poor water quality management, poor fish health management and lack of awareness and knowledge on fish diseases and causative agents. Overall, there is a need for further research and surveillance as well as extension services for fish farmers.

Keywords: Aquaculture, *Oreochromis niloticus*, *Pseudomonas* species, Prevalence, 16S rRNA.

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Light Colour Affect the Survival Rate, Growth Performance, Cortisol Level, Body Composition, and Digestive Enzymes Activities of Different Snubnose pompano (*Trachinotus blochii*, Lacépède, 1801) Larval Stages

John Mapunda ^{1,c,*}, Matern S.P. Mtolera ^a, Saleh A.S. Yahya ^a, Van Manh Ngo ^b, Matan Golan^d

Abstract

Snubnose pompano (*Trachinotus blochii*) are widely cultured in the world. Light colours are among factors affecting fish performance in captivity. Snubnose pompano larvae often reared under white light. However, no study supports its choice or informs the extent of its effect or its constituent colour. The study investigated the influence of green, blue, yellow, purple, and white lights on the growth, survival, cortisol, body composition, and digestive enzymes activities of one-day post-hatch Snubnose pompano larvae reared in light magenta tanks under a photoperiod of 24 Light:0 Dark hours for 25 days. Overall, the best growth performance of snubnose pompano larvae was in purple and white, and green lights during early and late larval stages, respectively. White light promoted the survival rate whereas that of greenlight reduced. Larvae were less stressed and had enhanced body contents under white and purple light environments. Purple and yellow lights influenced low trypsin and pepsin activities. The study reports for the first time the effect of the light colour environment on the digestive enzyme activities and body composition of the finfish larvae. The study provides novel insights into optimal light colour in the larval rearing protocol of this species. Through this study, the use of white light during the first feeding (zero to four days post-hatch) and purple light in later stages (five days post-hatch until metamorphosis) is encouraged while discouraging green and yellow lights in the larval rearing of Snubnose pompano.

Keywords: Snubnose pompano Light colour Growth Cortisol Digestive enzymes Body composition

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Supplementing Wastewater with NPK Fertiliser as a Cheap Source of Nutrients in Cultivating Live Food (*Chlorella Vulgaris*)

Kulwa Mtaki*, Margareth S. Kyewalyanga and Matern S.P. Mtolera

Abstract

The decline in fishery resources from the wild has led to an ever-increasing focus on aquaculture in recent years. With increasing aquaculture of animal species, there is an increasing need for suitable micro algae in the production of these animals. However, cultivation of micro algae inexpensive pure chemical media is one of the major challenges facing large-scale cultivation of micro algae. The present study investigated the suitability of aquaculture wastewater (AWW) supplemented with NPK(nitrogen: phosphorus: potassium) fertiliser as a cheap source of nutrient to cultivate a micro alga *Chlorellavulgaris* (*C.vulgaris*). *C. vulgaris* with an initial cell density of 0.8×10^6 cells/mL was batch cultured in AWW supplemented with NPK at 0.1, 0.5, 1.0 g/L and BBM for 20 days under laboratory conditions using 2000 mL Erlenmeyer flasks. The proximate composition, chlorophyll, minerals, and vitamins analysis of *C.vulgaris* biomass were done using standard analytical methods. The highest values in optical density (4.872 ± 0.025), dry cell weight(2.858 ± 0.015 g/L), specific growth rate(0.2097 ± 0.0038 day⁻¹), and biomass productivity (0.1701 ± 0.0007 g/L/day) were obtained in *C.vulgaris* grown in AWW+1.0NPK medium. The total chlorophyll, protein, lipid, and carbohydrate content of the micro algae biomass were in the range of 0.05–0.862%, 44.062–57.089%, 17.064–23.260%, and 15.217–21.896%, respectively. Furthermore, micro algae grown in AWW+1.0NPK showed good vitamin and mineral content compared to BBM grown alga. These findings indicated that the AWW+0.1NPK, AWW+0.5NPK, and AWW+1.0NPK are potential growth media for *C.vulgaris* cultivation and can replace the BBM medium, which is very expensive and less accessible to users.

Keywords: *Chlorellavulgaris*, Microalgae, Aquaculture wastewater, NPK

Effects of Different Types of Manure on the Culture of Marine Plankton as a Potential Source of Food for Mariculture Hatcheries

Fadhili M. Malesa^{1*}, Margareth S. Kyewalyanga², Rose J. Masalu³,
Matern S. Mtolera^{2,4}

Abstract

The study examined varied types of organic manure on the culture of marine plankton as a potential source of food for rabbitfish, *Siganus stellatus*, larvae. Cow-dung showed significantly higher species abundance and diversity of cultured marine plankton followed by chicken and, finally, mixed media manure ($p < 0.05$). In all, 36 genera of phytoplankton (21) and zooplankton (15) were identified in all culture media. Class Bacillariophyta was the most abundant and diverse group, which accounted for 41.3 % of the phytoplankton. Calanoida was the dominant group of the zooplankton identified, accounting for 51.7 %. It was observed that the organic manure used favoured the growth of commercially important species of phytoplankton such as *Chaetoceros* sp., *Skeletonema* sp., *Chlorella* sp., *Isochrysis* sp., *Nannochloropsis* sp. and *Spirulina* sp., and zooplankton such as *Eurytemora* sp., *Calanus* sp., *Oithona* sp., *Branchionus* sp., *Moina* sp. and ostracods. The growth performance and survival rate of early-stage rabbitfish larvae fed with live marine zooplankton performed better than those fed with *Artemia* spp. and commercial dry feed. In other words, zooplankton have the potential to enhance the growth performance and survival rate, hence boosting productivity and the development of mariculture.

Keywords: Marine plankton, Organic manure, Cow-dung, Chicken droppings, Mariculture

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Seagrass Meadows Mixed with Calcareous Algae have Higher Plant Productivity and Sedimentary Blue Carbon Storage

Olivia J. Kalokora¹, Martin Gullström², Amelia S. Buriyo³,
Matern S. P. Mtolera⁴ & Mats Björk^{5,*}

Abstract

Seagrass meadows capture and store substantial amounts of carbon in the sediment beneath, thereby serving as efficient sinks of atmospheric CO₂. Carbon sequestration levels may, however, differ significantly among meadows, depending on the plant community composition. Tropical seagrass meadows are often inter-mixed with macro algae, many of which are calcareous, which may compete with seagrass for nutrients, light and space. Though the photosynthetic CO₂ uptake by both seagrasses and calcareous algae may increase pH, the calcification process of calcareous algae may release CO₂ and, thus, alter the pH dynamics of the system differently, thereby affecting both productivity and calcification and, eventually, the meadows' carbon storage. This study estimated how plant productivity, CaCO₃ production and sediment carbon levels were affected by plant community composition (seagrass and calcareous algae) in a tropical seagrass-dominated embayment (Zanzibar, Tanzania). Overall, the patterns of variability in productivity differed between the plant types, with net areal biomass productivity being highest in meadows containing both seagrass and calcareous algae. A low and intermediate density of calcareous algae enhanced seagrass biomass growth, while a presence of seagrass reduced the productivity of calcareous algae but increased their CaCO₃ content. Sedimentary carbon levels were the highest when seagrasses were mixed with low or intermediate coverage of calcareous algae. The findings show that plant community composition can be an important driver for ecosystem productivity and blue carbon sequestration.

Keywords: Interaction, *Halimeda opuntia*, calcification, *Thalassia hemprichii*, productivity, blue carbon.

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Methane Emission and Sulfide Levels Increase in Tropical Seagrass Sediments during Temperature Stress: A Mesocosm Experiment

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Abstract

Climate change-induced ocean warming is expected to significantly affect carbon dynamics and sequestration in vegetated shallow waters, especially in the upper subtidal where water temperatures may fluctuate considerably and can reach elevated levels at low tides. This might alter the greenhouse gas balance and significantly reduce the carbon sink potential of tropical seagrass meadows. To assess such consequences, we simulated temperature stress during low tide exposures by subjecting seagrass plants (*Thalassia hemprichii*) and associated sediments to elevated midday temperature spikes (31, 35, 37, 40, and 45°C) for seven consecutive days in an outdoor mesocosm setup. During the experiment, methane release from the sediment surface was estimated using gas chromatography. Sulfide concentration in the sediment pore water was determined spectrophotometrically, and the plant's photosynthetic capacity as electron transport rate (ETR), and maximum quantum yield (Fv/Fm) was assessed using pulse amplitude modulated (PAM) fluorometry. The highest temperature treatments (40 and 45°C) had a clear positive effect on methane emission and the level of sulfide in the sediment and, at the same time, clear negative effects on the photosynthetic performance of seagrass plants. The effects observed by temperature stress were immediate (within hours) and seen in all response variables, including ETR, Fv/Fm, methane emission, and sulfide levels. In addition, both the methane emission and the size of the sulfide pool already negatively correlated with changes in the photosynthetic rate (ETR) during the first day, and with time, the correlations strengthened even further. These findings show that increased temperature will reduce primary productivity and increase methane and sulfide levels. Future increases in the frequency and severity of extreme temperature events could, hence, reduce the climate mitigation capacity of tropical seagrass meadows by reducing CO₂ sequestration, increase damage from sulfide toxicity, and induce the release of larger amounts of methane.

Assessing the Genetic Diversity of Farmed and Wild Rufiji Tilapia (*Oreochromis Urolepis Urolepis*) Populations using ddRAD Sequencing

Christer S. Nyinondi^{1,2} Matern S. P. Mtolera² Aviti J. Mmochi² Fernando A. Lopes Pinto¹ Ross D. Houston³ Dirk J. de Koning¹ Christos Palaiokostas^{1,3}

Abstract

Rufiji tilapia (*Oreochromis urolepis urolepis*) is an endemic cichlid in Tanzania. In addition to its importance for biodiversity conservation, Rufiji tilapia is also attractive for farming due to its high growth rate, salinity tolerance, and the production of all-male hybrids when crossed with Nile tilapia (*Oreochromis niloticus*). The current study assessed the genetic diversity and population structure of both wild and farmed Rufiji tilapia populations to inform conservation and aquaculture practices. Double-digest restriction-site-associated DNA (ddRAD) libraries were constructed from 195 animals originating from eight wild (Nyamisati, Utete, Mansi, Mindu, Wami, Ruaha, Kibasira, and Kilola) and two farmed (Bwawani and Chemchem) populations. The single nucleotide polymorphisms (SNPs; $n = 2,182$) identified helped to investigate the genetic variation within and among the studied populations. Genetic distance estimates (F_{st}) were low among populations from neighbouring locations, except for Utete and Chemchem populations ($F_{st} = 0.34$). Isolation by-distance (IBD) analysis among the wild populations did not detect any significant correlation signal ($r = .05$; p -value = .4) between the genetic distance and the sampling (Euclidean distance) locations. Population structure and putative ancestry were further investigated using both Bayesian (Structure) and multivariate approaches (discriminant analysis of principal components). Both analyses indicated the existence of three distinct genetic clusters. Two cross-validation scenarios were conducted to test the efficiency of the SNP dataset for discriminating between farmed and wild animals or predicting the population of origin.

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About 95% of the test dataset was correctly classified in the first scenario whereas predicting the population of origin 68% of the test dataset was correctly classified. Overall, our results provide novel insights regarding the population structure of Rufiji tilapia and a new database of informative SNP markers for both conservation management and aquaculture activities.

Keywords: ddRAD-seq, genetic diversity, Rufiji tilapia

Sub-Theme 7: Smart Energy Systems

Identity and Access Management for Distributed Devices for IoT-Enabled Distribution Automation in Electrical Secondary Distribution Network

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Abstract

The combination of the Internet of Things and smart grid technologies plays a vital role in improving the quality of service offered in future electrical grid systems. The introduction of demand response and distribution automation offers significant advantages to both utility companies and final consumers. However, integrating these advanced technologies in legacy electrical grids imposes security challenges. An attacker can introduce a fake node into the system that can transmit wrong reading, resulting in false alarm reports, leading to improper control commands sent to control wrong actuating nodes. On the other hand, a fake actuating node can send unintended commands to control system devices and report wrong system devices that could be disastrous. Like reporting, the control switch status is open while the actual status remains closed. Finally, a fake control node can permit malicious users to control other system devices. Identity and access management security scheme is, therefore, proposed for IoT—Enabled distribution automation to overcome these challenges. The scheme can identify, authenticate and authorise both system users and nodes. The proposed scheme can also prevent non-legitimate users from accessing the system while controlling authenticated users to access only authorised services based on their role. In fact, only registered nodes can communicate with other legitimate nodes. Each node can operate based on the role and type, whether a sensor, an actuator, an edge or a fog device.

Keywords: Identity and Access Management, Internet of Things, Smart Grid, IoT Enabled Distribution Automation, Secondary Distribution Network.

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Applications Monitoring Platform for Fault Detection and Clearance in Electrical Secondary Distribution Network

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Abstract

Cloud computing has been a dominating technology for smart grid applications because of its ability to provide on-demand computing services. However, cloud computing poses challenges related to latency, location restrictions and mobility support. Fog computing has been conceptualised as an extension to cloud computing to address these issues. Fog computing allows processing to be at edges, closer to the source of data through fog node. Fog nodes have fewer computing resources than cloud. Therefore, more demanding applications are migrated between fog nodes and clouds depending on the processing requirements. The migration of applications is facilitated by virtualisation technologies, particularly, the use of virtual machine and containers. In this paper, the interest is to propose a platform that facilitates the co-ordination of fault clearance applications by offering computing resource usage monitoring. The focus of the platform is to use dynamically and adaptively these metrics to co-ordinate applications between fog nodes and the cloud without necessarily affecting the minimum performance required. The co-ordination decision-making process may be based on location, traffic load reduction, storage capacity, network capacity, application behaviour, energy conservation, service replacement, and heterogeneity. The proposed architecture is demonstrated alongside evaluation metrics.

Keywords: Fault Detection, Fault Clearance, Distributed Processing, Secondary Distribution Network, Remote Sensing Unit

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Software Defined Sensor Network (SDSeN) Simulation Framework for Secondary Distribution Power Network

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Abstract

A well-dimensioned and robust communication architecture is important for smart grid (SG) applications. Setting a real communication architecture up for SG research purposes can be expensive, hence making it physically unfeasible for researchers as it requires real network devices, space, and infrastructure. In SG infrastructure, end devices need to communicate with central or controlling devices so that SG applications can run smoothly. From literature, it is evident that most power utilities have already deployed solutions aimed to automate the power generation part, power transmission part and primary distribution part of the grid; however, the secondary distribution power network (SDPN) is the least invested in and is unmonitored due to the elevated level of investment needed for automating it. In this paper, a real time simulation platform for SDPN end nodes for SG applications is developed. The developed platform developed can simulate complex SG SDPN models with large numbers of end devices (sensors, smart meters and actuators) in real time. This developed platform is versatile in a way it allows for custom definition of the researcher's environment such as defining the size of coverage area, number of devices, size and routing of data being sent in a network and defining protocols. A case study was demonstrated using the developed platform; real SDPN data collected from the Tanzania grid was used for simulation. The results validated the use of the platform for SDPNSG application simulations.

Keywords: Communication architecture, sensor network, end devices, smart grid, software defined network, secondary distribution power network.

Fault and Restoration-Based Load Demand Forecasting Mechanism for Automatic Fault Clearance using Real-Time Long-Term Power Consumption Determinants: A Smart Grid Initiative to Establish Robust Load Forecasting Mechanism for Automatic Fault Clearance in Tanzania

Hussein Bakiri¹, Hellen Maziku, Nerey Mvungi, Libe Massawe,
Hamisi Ndyetabura

Abstract

Smart grid technology is an emerging platform adopted by many electric power utility companies to enhance proper service delivery and engender cost-effective operations. Automatic Fault Clearance (AFC) is a part of smart grid initiatives aimed to detect, manage and handle faults with little or without human intervention. As one of the components of AFC, load demand forecasting agency plays a crucial role in feeding restoration and distributed energy resource agencies. Forecasting load demand profile in the AFC requires robust mechanism for accommodating both real-time and fault-based occasions. Due to the non-stationary load pattern exhibited in Tanzania, the Load Demand Forecasting (LDF) is supposed to establish mechanism for handling abnormal annual load growth. However, the existing LDF mechanisms for service restoration do not address issues of non-stationary load patterns, fault-driven and real time forecasting. Therefore, the aim of this research is to propose a fault-based and real-time LDF mechanism for non-stationary data in the automatic fault clearance context. We, firstly, established the design requirements using focus group discussions and literature reviews. Secondly, we conducted iterative validation to assess the suitability of the proposed LDF mechanism in the intended context. Thirdly, we achieved the core forecasting part of the mechanism using the extended Multivariate Nonlinear Regression (e-MNLR) model. Findings indicate the capability of the proposed mechanism to forecast the next load demand profile from fault-date, fault-time, restoration duration, Gross-Domestic Product (GDP), number of customers and population information. Furthermore, the designed e-MNLR model outperforms the ANN, SVM, LSTM and MNLR models.

Keywords: Smart Grid; Automatic Fault Clearance; Load Forecasting; Extended-MNLR

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Grid Connected PV-Wind Energy System for Luxmanda Village in Tanzania

Lucy J. Fungo^{1,2}, Aviti T. Mushi¹, and Consalva J. Msigwa²

Abstract

There are rural areas in Tanzania, which still lack access to the national grid. One of such locations is Luxmanda village in Manyara region. This village gets its power from islanded renewable energies micro-grid (MG), which can supply about 25.4kW. However, this is below the projected consumption. Therefore, this paper proposes connecting the islanded MG to the grid to supply enough power to the village for prosperity. The paper discusses the solar photovoltaic generation, wind generation and the DC grid. A steady state of operating the MG is established at 750 V DC.

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Proposing Mixed Coupled Hybrid Renewable Energy Sources for Mwanza International Airport

Monyiachi N. Minja^{1,2} and Aviti T. Mushi¹

Abstract:

Mwanza International Airport (MIA) consumes about 18 MVA annually. Implicitly, it is expensive to depend exclusively on the grid and the backup diesel generator (DG). This paper, therefore, proposes mixed coupled hybrid renewable energy sources (MCHRES) to power the airport. This energy mix constitutes solar photovoltaic (PV), wind, DG and a battery. These energy estimates are based on the site data, and the power system components so designed and their prices as presented. The project costs are reasonable and justify the potential of the estimated energy.

Keywords: MCHRES, solar PV, wind, airport power

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DC Voltage Regulation of Solar PV/ Wind and Biofuel Hybrid System Incorporating Battery Storage

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Abstract

Tanzania has several places lacking access to the national electricity grid. These areas can be powered by utilising hybrid energy systems (HES) such as solar photovoltaic, wind, and biodiesel. However, such a system produces voltage control challenges at the DC bus due to stochastic nature of those sources if the battery is not coupled. Therefore, this paper first proposes an HES coupled with a battery. Secondly, it proposes control that can regulate the three sources of energy such that the DC bus is maintained at 750 V. Simulation results have shown that a conventional proportional and integral controller can achieve DC bus voltage regulation for the system proposed in this paper regardless of irradiance variation, wind speed variation, or the load variation. This type of energy sources is feasible for use in the rural areas of Tanzania.

Keywords: Hybridenergy system, Biodiesel, DC-DC boost converter, solar photovoltaic

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Comparison of Mitigation Techniques of Harmonic Filters for Non-Linear Load

N.H Kuchi, E. S. Matee, C. J. Msigwa.

Abstract

This paper presents different filter designs used to mitigate harmonics in standalone renewable energy systems. Harmonic current or voltage is a multiple integer of system frequency, which causes the distortion of the otherwise system voltage because of increasing non-linear loads uses in the power system. This development affects the system performance and gives undesirable moments such as power losses in the distribution, equipment over-heating, etc. The key object of this paper is to compare the performance of the passive filter and active filter on the standalone renewable system. These filters are very effective in the reduction of harmonics and distortion in voltage caused by non-linear load. Results of the comparison shows that the active filters perform better in the reduction of harmonics distortion than the passive filters.

Keywords: Fundamental frequency, Harmonics, Harmonics filter, Linear load, Non-linear load, Passive filter, Active filter

MPPT-based Solar PV System with DC Voltage Regulation for Ikuza Island

Nassoro S. Nassoro¹, Bakari Mwinyiwiwa² and Consalva J.Msigwa³

Abstract

Currently, the sources of electric power on Ikuza Island comprise small diesel/petrol generators and some use solar home systems. Those systems are not reliable for Ikuza Island since diesel/petrol generators have high operating cost and cause environmental pollution. This paper presents the MPPT-based Solar PV system using incremental conductance algorithm. The proposed system was simulated with MATLAB/Simulink and successfully attained the maximum power and managed to keep the DC bus voltage constant under variation of solar irradiance.

Keywords: Solar PV, MPPT, Boost Converter, Incremental Conductance.

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Multi-Agent based Fault Localisation and Service Restoration in Tanzania's Secondary Distribution Network

Rukia J. Mwifunyi, Nerey H. Mvungi, Mussa M Kissaka

Abstract

Fault Localisation and Service Restoration (FLSR) is a fundamental function during the fault management process of a distribution system for improved service reliability and resilience. Approaches devised to solve the FLSR problem include centralised and distributed ones. In Tanzania, fault management in a Secondary Distribution Network (SDN) is accomplished manually through customers calls and manual line inspections. Decision on restoring service relies on prior experiences, rated capacity of transformers and peak hour demand causing prolonged service restoration and load shedding. This study aimed to design and develop a distributed algorithm based on multi-agent system for FLSR in SDN. To begin with data were generated from focus group discussions held with key stakeholders drawn from the power utility company, study visits to the Tanzania SDN in Dar es Salaam region, interviews held with the technical personnel, and intensive literature review which informed the designing of a multi-agent system. Five agents namely Control Agent, Grid Agent, Load Agent, Renewable Distributed Generation Agent and Switch Agent have been developed to support the FLSR process. The agents facilitated decision-making, fault localisation, restoration process through load transfer to nearby transformers and/or renewable energy sources and load shedding. The future work will focus on the real deployment and testing of the developed algorithm on a real power system.

Keywords: Fault Location; Service Restoration; Multi-Agent System; Distributed Control; Load Shedding.

SDN-Based Communication Network Resilience for Secondary Distribution Electric Power Grid

Yona Andegelile, M. M. Kissaka and N. H. Mvungi

Abstract

Secondary Distribution Electrical Power Grid (SDEPG) is the last mile of the electrical power grid that connects end-users. SDEPG includes voltage ranges from 0.4 kV to 11 kV. Moving from a traditional SDEPG to a smart SDEPG calls for having place a reliable communication network, which can still provide service in case of any challenge. Factors that affect the reliability of the communication network for SDEPG include availability, bandwidth and latency, the most critical being availability. Unreliable communication results in an unmanageable power grid, hence leading to uncontrolled failures that can negatively impact on humankind. Flexibility and programmability brought by Software Defined Networking (SDN) have made it superior in enhancing communication network reliability, thus attracting a lot of research in this area. Currently, most research focuses on ensuring resilience in IP networks with wired technologies. However, the nature of SDEPG demands a combination of wired and wireless technologies, hence requiring a solution that cuts across all technologies. This paper proposes an SDN-based resilience solution for the SDEPG communication network that cuts across all layers. The solution exploits the Odin framework's capabilities to implement wireless LAN virtualisation in a bid to enhance communication network resilience. The solution was implemented in a laboratory setup, and failure scenarios were simulated. The bandwidth obtained, latency and availability were compared with the SDEPG requirement. Overall, the results demonstrated the potential of the proposed solution in providing a resilient communication network to facilitate SDEPG automation.

Keywords: Resilience; Secondary Distribution Electrical Power Grid; Software-defined networking

Predictive Torque Control of MW-Class Direct Drive Back-to-Back 2-Level-VSC-BASED SPMSG WECS

Yusuph Adam^{1,2}, Fransic Mwasilu¹, and Consalva J. Msigwa²

Abstract

This paper proposes predictive torque control (PTC) for the machine-side converter (MSC) in the gearless permanent magnet synchronous generator-based wind turbines. For the proposed control scheme, the reference torque in Surface-PMSG(SPMSG) is obtained through optimum torque maximum power point tracking (OT MPPT) algorithm in combination with zero d-axis control (ZDC) strategy. The generator-side cost function evaluates the error between the reference and predicted values, the switching states that minimise the cost function are selected and directly applied to the 2L-VSR. In this control scheme, predicted torque is seen to track reference torque at any given windspeed. The feasibility of the proposed scheme is verified through simulation results using 3-MW wind turbine system.

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**Sub-Theme 8:
Sustainable Water Resources
Management**

Key Players/Actors for Reducing Rural Women's Workload of Fetching Water in Busega District, Tanzania

Deborah Andrew Ngusa¹

Abstract

Key players/actors involved in supplying water services in the community contribute to the reduction of the workload for rural women of walking over long distances. Specifically, the study examined key players/actors with their structures applied for providing services expected to enhance sustainable access to and use of water among rural women in Busega district, Tanzania. The study adopted Triple-S (Sustainable Services at Scale) to analyse key players/actors such government agencies, Non-governmental Organisations (NGOs) and individuals who provide water services to rural women. The study was conducted using a cross-sectional research design to collect quantitative and qualitative data. Primary data collection methods included household survey, focus group discussions and non-participant observations. The instruments used for data collection were questionnaires, observations, interview guides and checklists. In addition, documentaries on water services in the district council were reviewed to collect secondary data. Likert-scale points, descriptive statistics, Chi-square and content analysis were used to analyse the resultant data. Results indicate that, there are some weaknesses in the management and administration of the structures key players applied for providing water services to rural women. The study concludes that, key players/actors have not been efficient in supporting the provision of rural women's access to and use of sustainable water services for domestic consumption. The study recommends that to ensure sustainable access to and use of water services in Tanzania's remote rural areas, the Ministry of Water and Irrigation should make sure that there are clear instructions and responsibilities among key players/actors to reduce structural weaknesses.

Key words: Key players/actors, rural women, water vendors and workload

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Validation and Prediction of Accuracy of Satellite-Based CHIRPS Rainfall Data

Deogratias M.M. Mulungu¹ and Erasto Mukama

Abstract

Rainfall is an important water resource for a wide array of socio-economic activities such as domestic and industrial water supply, agriculture, hydropower generation, fish farming, river and lake navigation. Also, rainfall plays a pivotal role when it comes to the occurrence of hydrologic extremes such as floods and droughts. Thus, rainfall data influences planning and management of the socio-economic activities. Rainfall data can be obtained from rain gauges or estimates from satellite or other means. In this study, Climate Hazards Infra-Red Precipitation with Station data (CHIRPS) satellite-based rainfall data were evaluated against ground observations. Its performance was evaluated during the 1981-2015 period. Results show that CHIRPS monthly data correlated well with ground rainfall observations with a Pearson correlation coefficient of $r > 0.7$, which was mainly in lowland areas and satisfactory to very good performance with a Percentage of Bias (PBIAS) $< 25\%$. Based on the t-test, the CHIRPS data was proved to be the same as that of ground rainfall ($p > 0.05$), except for some stations with higher Absolute bias (ABIAS) ($> 17\%$) whereby the rainfall data was incongruent. As a quick guide, ABIAS $> 17\%$ can be used to indicate significant differences or the need to carry out a t-test on monthly CHIRPS data in case of uncertainty. Also, it was shown that ABIAS and p-value from t-test results are highly negatively correlated. As a result, this study developed an innovative linear relationship between ABIAS and p-values from the rainfall stations, which can be used to infer acceptance/rejection of null hypothesis given the BIAS monthly. These simple models are important and can help to quickly indicate the suitability of CHIRPS data in a basin without/before going into the rigorous t-tests on operational basis. Overall, CHIRPS rainfall monthly data showed relatively superior performance, hence warranting its use for hydrological and water resources management studies in the basin.

Keywords: Bias, CHIRPS, Ground observations, Ruvu basin, Satellite products, Water resources management

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Sub-Theme 9: Safe Drinking Water

Simultaneous Removal of Fluoride and Arsenic from Water by Hybrid Al-Fe Electrocoagulation: Process Optimisation through Surface Response Method.

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Abstract

The electrocoagulation process using hybrid aluminium-iron electrode was used for removing arsenic and fluoride from water. The operation parameters—current density, initial pH, treatment time, initial concentration of arsenic and fluoride—were optimised using the Box Behnken Design. The R^2 values for arsenic and fluoride removal were 0.83 and 0.96, respectively, which were satisfactory for developing a quadratic model. At optimised operation parameter of 9.90 mAcm^{-2} , pH 7.5, the Al-Fe EC reduced 16 mg/L and arsenic $200 \text{ }\mu\text{g/L}$ to 1.12 mg/L and $9.60 \text{ }\mu\text{g/L}$, respectively, in 50 minutes with an operation cost estimated at $0.99 \text{ \$/m}^3$.

Keywords: Electrocoagulation; groundwater; arsenic; fluoride; reduction; response surface methodology

Effects of Co-existing ions on Simultaneous Removal of Fluoride and Arsenic from Water by Hybrid Al-Fe Electrocoagulation

Magori J. Nyangi^{a,b}, Yona Chebude^a, Kessy F. Kilulya^c Andrew Minu^d

Abstract

The effects of co-existing ions in water such as Ca^{2+} , Mg^{2+} , NO_3^- , SO_4^{2-} and HCO^- on the simultaneous removal of F^- (16 mg/L) and As^{3+} (200 $\mu\text{g/L}$) using hybrid Al-Fe electrocoagulation were evaluated using the Box-Behnken design. Experiments were conducted on operation conditions of $J = 9.9$ mA/cm², $\text{pH} = 7.5$ and 50 min. The analysis of variance results for all the variables confirmed the predicted models by the experimental design R^2 : 0.69 and 0.72 % for F- and As^{3+} , respectively, which ensured a fairly satisfactory adjustment of the quadratic models with the experimental data. The results indicate that Ca^{2+} (0.5-100 mg/L) enhanced F- removal, while SO_4^{2-} (> 80 mg/L) and NO_3^- (> 75 mg/L) suppressed the F- removal. On the other hand, NO_3^- (0.5-100 mg/L), SO_4^{2-} (> 50 mg/L), Mg^{2+} (> 50 mg/L), and Ca^{2+} (> 50 mg/L) reduced As^{3+} removal. The combination of Mg^{2+} (< 70 mg/L) and Ca^{2+} appears to increase the fluoride removal whereas the combination of other ions had antagonistic effects on the removal of both F- and As^{3+} . Carbonates showed an insignificant influence on the removal of both pollutants. The effect of co-existing ions on the performance of hybrid Al-Fe EC was found to depend on the type and concentration of individual co-ion.

Keywords: Arsenic, fluoride, electrocoagulation, Box Behnken design, co-existing ions

Arsenic Removal Using Locally Available Gypsum Minerals in Tanzania

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Abstract

Arsenic (As) is a toxic metalloid causing severe health challenges to the population's Long-term exposure to As by drinking water from groundwater sources, eating food or inhaling dust can trigger severe health impacts on humans such as skin disorders and damage to internal organs such as the kidney and liver, often leading to cancer. Thus, there is an urgent need to develop affordable technique for As removal. It is important to reduce exposure to As and save human lives. Locally available minerals such as gypsum has been used for As stabilisation before depositing to landfills. To understand the process of As removal, gypsum mineral powder of 0.075 mm grain size was characterised by X-ray Diffractometry (XRD). The XRD data revealed the presence of calcium sulphate, calcium carbonate, iron sulfide, mineral phases of As complexed with nickel, copper and gallium. The scanning electron microscopy-energy dispersive spectroscopy (SEM-EDS) confirmed the presence of heterogeneous surface providing multiple sites for As adsorption. Laboratory batch experiments with the application of gypsum on water sample from Geita, Tanzania, revealed removal of 84% As (V) and 98% As(III) within the first 30min. In natural water, gypsum showed the removal of both As(V) and As(III). The adsorption process augured well with Freundlich isotherm, which means the presence of multilayer As uptake with R^2 of 0.9875, n of 1.36, k_f 0.034mg/g. The process obeys pseudo second order kinetics with R^2 0.99, q_e 0.067mg/g, K_2 0.79g/mg min. The best working pH on As adsorption onto gypsum was starting with neutral pH 7. Gypsum was also found to be effective for removal of As from solutions

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with high concentration levels up to 5 mg/L using 1 g of the adsorbent that could remove 60% in the batch experimental runs in 240 min. Therefore, the study recommend for gypsum to serve as a low-cost adsorbent material for the removal of As from drinking water sources in Tanzania.

Key words: Arsenic, groundwater, drinking water, gypsum, removal, adsorption, pH.

Machine Learning Approach to Understanding Co-occurrence and Spatial Variability of Geogenic Contaminants in Drinking Water Sources of North-West Tanzania

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Abstract

The presence of geogenic contaminants such as arsenic (As) and fluoride (F⁻) and other potentially toxic elements (PTE) in groundwater systems in the arid and semi-arid regions of the world significantly challenges access to safe drinking water. For economic reasons and accessibility issues, particularly in developing countries, most aquifers are less sampled, hence leading to inadequate data for understanding the geochemical processes triggering the spatial variability of such contaminants using conventional methods. In this study, the machine learning approach was used to characterise the co-occurrence and spatial variability of arsenic (As) and fluoride (F⁻) in the Precambrian basement aquifers of north-west Tanzania. The study was based on 130 groundwater samples from drinking water sources in 13 wards of the Geita district, south of Lake Victoria in the vicinity of small- and large-scale gold mining sites. The robust exploratory spatial data analysis methods were used to study the spatial variability in As and F⁻ concentrations. These methods included the integration of global indicators of spatial association,

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local indicators of spatial association and Geographical Information Systems. Arsenic concentrations ranged between 0 and 290 ppb whereas that of F⁻ ranged between 0.09 and 2.17 mg/L. Around 82% and 5% of drinking water sources had As and F⁻ concentrations exceeding the recommended values of 10 ppb and 1.5 mg/L, respectively. Concentrations for chemical elements clustered in space as indicated by a positive and significant Moran's I (I=0.339, z-value= 6.36, p-value= 0.001 for As and I=0.485, z-value=8.56 and p-value= 0.001 for F). Most of the drinking water sources contaminated by both As and F⁻ were spatially distributed in the northeast of the study area and formed significant spatial patterns. Arsenic concentrations demonstrated high spatial variability in the highlands whereas F⁻ concentrations demonstrated the highest spatial variability in the lowlands. In the highlands, groundwater was acidic with a mean pH of below 6.5, suggesting that As is mobilised through the oxidative-dissolution of As-bearing minerals such as pyrites, arsenopyrites, and chalcopyrite present in rocks exposed to air by ongoing mining activities. The pH in the lowlands was slightly lower than the neutral value of 7.0, hence complicating the interpretation of the sources of elevated F⁻ in groundwater. Since the lowlands are dominated by human settlements with people engaging in agriculture, anthropogenic sources could be contributing to the contamination of drinking water sources by F⁻.

Keywords: Groundwater quality, arsenic and fluoride co-occurrence, spatial variability, deep learning, Precambrian basement aquifers, north-west Tanzania.

A Column design with low-cost adsorbent for hard water treatment: A case study of Dodoma City

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Abstract

In this work a column design with low-cost adsorbent for hard water treatment was designed. The column reduces hardness from DUWASA pipeline system. The total hardness, calcium hardness and magnesium hardness was reduced by 32.81%, 22.44% and 89.85%, respectively. The research is still in progress to meet TBS-standards and improve the operation of the column for effective and efficient process.

Keywords: Column design, Low-Cost Adsorbent, Cactus Material, Water Treatment, Dodoma City.

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Sub-Theme 10: Sanitation Management

Improving Menstrual Hygiene Management in Secondary Schools

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Abstract

The rapid increase in secondary school students' enrolment since the implementation of Secondary Education Development Programme (SEDP) has placed a heavy burden on the existing infrastructure, particularly WASH facilities. As a result, the number of schools and students in Tanzania has increased tremendously in recent years, particularly in community schools. The rapid increase in the number of students was not coupled with a concomitant increase in sanitary facilities, including menstruation facilities. Failure to provide appropriate menstrual hygiene facilities at home or school could affect how WASH services being used. Adolescent females at schools demand adequate sanitary facilities for managing their menstrual wastes at school. Managing menstruation requires the use of disposable and non- disposable sanitary towels. Disposable sanitary towels are the most frequently used methods to manage menstruation. In fact, 70% of the girls/women in Tanzania prefer to use disposable pads. This work aimed to understand the situation on menstrual hygiene practices and how menstrual wastes are comparatively managed between private and public schools. Also, the formulation and implementation of policies that promote the reproductive health and education rights of female students by tackling problems associated with managing menstrual flow and by improving access to appropriate menstrual waste disposal. Results show that about 97.1% of the schoolgirls were found to use disposable sanitary pads as their only absorbent material during their last menstruation at school and 2.9% used a rag. Thus, sanitary towels (pads) were described by almost all girls' students as their preferred method for managing menstruation. There is the lack of or inadequate of safe disposal facilities for menstrual waste materials. Schoolgirls are being forced to dispose them in school latrines which frequent filling up of latrine in public schools. Further, it was observed that toilets were in bad use condition meaning that there was no privacy, water, hand washing and collection facilities. To

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improve the MHM, the government should subsidise the price of sanitary pads and other menstrual flow commodities to make them more affordable to schoolgirls. Municipalities should ensure that all schools comply with the MH waste management guidelines available to foster safe disposal.

Keywords: Menstrual hygiene management, menstrual waste, secondary schools, pads

Examining the Performance of High-Rate Algal Pond (HRAP) as an Alternative Wastewater Treatment Option to Conventional Waste Stabilisation Ponds

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Abstract

The High-Rate Algal Pond (HRAPs) is increasingly becoming a preferred wastewater treatment technology option over conventional wastewater stabilisation pond (WSPs). This paper presents the results of the potential application of HRAPs for the treatment of domestic wastewater over conventional WSPs. The study was conducted to determine the treatment performance of HRAPs wastewater treatment technology. Sampling was carried out three times a week and involved taking domestic wastewater samples at the influent and effluent of both HRAPs and conventional WSPs. Results show that, the high-rate algal pond removed more nutrients, BOD, COD and faecal coliforms than conventional ponds. The treatment removal efficiency for BOD₅ and COD was 44.48% and 43.93%, respectively, in HRAP whereas in conventional WSPs, the removal efficiency for BOD and COD was 17.57% and 18.20%, respectively. Organic nitrogen was removed by 34.18% in HRAP whereas in WSP1 and WSP2 the removal efficiency was 7.05% and 13.8%, respectively. NH₃⁺-N was removed by 68.95% against 22.66% in WSP1. From multiple regression analysis, there is statistically significant evidence that pH, DO, Org-N, and NO₃-N had significant effect on reducing NH₃-N by (-6.04908, -0.84667, -0.20789 and -0.11564) mg/l coefficients, respectively. Temperature, pH, DO, EC, and NH₃-N had significant effect on NO₃-N with *p* values of 0.0000, 0.0000, 0.0030, 0.0000 and 0.0050 respectively. Nitrogen had been removed by 34.18%, 68.95% and -209.89% in form of Org-N, NH₃-N and NO₃-N respectively. Faecal coliform counts were reduced from 3.00x10⁸Cfu /100 ml from Influent (IF) to 1.45 x 10⁸ in WSP1 with the removal efficiency of 51.79% whereas in HRAP Faecal coliform counts were reduced to 4.46x10⁵Cfu /100 ml with removal efficiency of 99.85%. Faecal coliforms mortality (FC) was largely

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contributed by pH 85% ($t = -5.3$, $p = 0.0000$). The conclusion of this study is that HRAP determines the nitrogen removal efficiency by reducing nitrogen concentrations as well as nitrogen transformation from one form to another, high rate of pathogens removal also implies better performance of HRAP over conventional ponds.

Keywords: High-Rate Algal Pond; Conventional pond; Nutrients, Pathogens, wastewater treatment

Upscaling the Use of Biodigester for Sustainable Treatment of Human Placenta in Health Care Facilities: Case of Mwananyamala

Susan Marco¹, Sara Gabriellsson^b, Richard Kimwaga^c, Aloyce.W Mayo^c

Abstract

Treating and disposing of biodegradable pathological waste is a growing concern for many healthcare facilities. All the categories of solid wastes generated by healthcare facilities need to be adequately managed to safeguard public and environmental health. In Tanzania, the main disposal methods for medical wastes in health care facilities comprised of open pit burning, burying and incineration. These methods have been linked to high operational costs, health and environmental risks to the operators. Most of special wastes such as the placenta are treated as regulated medical wastes (RMW). Although there are many options for managing regulated medical wastes, the incineration is the most common method applied worldwide, especially the onsite incineration. Incinerators are associated with high operational costs because of high moisture contents in the human placenta. Yet very few studies have been conducted on the proper management of the regulated medical wastes, placenta being one of them in the localised context of Tanzania. To address the human placenta management challenge, the Mwananyamala Referral Hospital in Dar es salaam piloted the use of an anaerobic bio-digester as an alternative sustainable method for the management of the human placenta waste generated in the hospital. Results show that the monthly cost for running incinerator in managing the placenta was TZS 420,000/= while the corresponding value for biodigester was TZS 150,000. Thus, the operation cost for treatment of human placenta waste by using digester is low. The generated biogas from bio-digester, which was subjected to the gas analyser model GIR5500, comprised Methane (CH₄) accounting for 83.2%. This CH₄ is pure combustible biogas. Carbon dioxide (CO₂), Hydrogen Sulphide (H₂S) and Oxygen accounted for 14%, 2.8% and

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0%, respectively. Hence there is enough biogas produced from the placenta fed into anaerobic digester. The co-digestion resulted into higher volume of biogas by 31.5% as compared to the placenta only. The use of the biodigester for human placenta treatment should be scaled up and health facilities should adopt their use as an alternative to incinerators and other methods.

Keywords: Human placenta waste, Anaerobic bio-digester, and Biogas

**Sub-Theme 11:
Mathematics in Higher Learning
Institutions**

Asymptotic Approximation of Misclassification Probabilities in Linear Discriminant Analysis with Repeated Measurements

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Abstract

In this paper, we propose asymptotic approximations for the probabilities of misclassification in linear discriminant analysis when the group means follow a growth curve structure. The discriminant function can classify a new observation vector of p repeated measurements into one of several multivariate normal populations with equal covariance matrix. We derive certain relations of the statistics under consideration to obtain asymptotic approximation of misclassification errors for the two group cases. Finally, we perform Monte Carlo simulations to evaluate the reliability of the proposed results.

Keywords: Asymptotic approximation, Growth Curve model, linear discriminant function, probability of misclassification.

Application of Multi-Criteria Decision-Making Methods in the Choice of Crops for Small-scale Agro-Processing: The Case of Njombe Region, Tanzania

Benito Gasper Mung'ong'o and David Koloseni

Abstract

The purpose of this study was to find out and prioritise the kind of crops small-scale farmers should grow most for processing in each ward of Njombe region. A decision was made to select crops that could be grown most for agro-processing. Multi-criteria decision-making methods were applied in prioritising the crops. The fuzzy TOPSIS method was used to assess the criteria for the study and ranked the alternatives for each of ten administrative wards of Njombe DC. The fuzzy AHP results were compared with those from the fuzzy TOPSIS method. Each ward's crops were assessed for each criterion by fuzzy AHP. Crops were ranked in each ward. The study found that maize ranked the highest in five of the ten wards. Other wards had different crops that ranked highest. This study was limited to the wards that were studied but a similar study and methodology can be applied in other geographical locations.

Keywords: Multi-criteria decision making, agro-processing, fuzzy TOPSIS, fuzzy AHP



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