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The 3rd Annual Conference on Research and Inclusive Development

Harnessing Research and Innovation for Sustainable and Inclusive Development in Tanzania

POLICY BRIEFS

UNIVERSITY OF DARES SALAAM

The 3rd Annual Conference on Research and Inclusive Development

Harnessing Research and Innovation for Sustainable and Inclusive Development in Tanzania

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Sub-Theme 1:

Engendering Agribusiness Entrepreneurship

Gender in Agricultural Sector in Tanzania: An Unfinished Ancillary Business?

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Abstract

Tanzania's agricultural regulatory framework comprising policies, strategies, and programme documents in Tanzania is by design pro-gender equality. There is, however, a gap between such policy frameworks and implementation. any of the gender equality related promises in the National Agricultural Policy (NAP), Agricultural Sector Development Strategy (ASDS), Agricultural Marketing Policy (AMP), Agricultural Sector Development Programme (ASDP II), and National Rice Development Strategy (NRDS II) have yet to materialise. The gender equality agenda is, thus an unfinished business deserving better policy guidance, implementation commitment, and evaluation throughout the policy process. This policy brief draws on documentary reviews and primary data from Kyela to propose actions for proper/better gender mainstreaming in Tanzania's agricultural sector.

Key messages

- The agricultural policy framework in Tanzania is by design pro-gender equality
- There is a mismatch between policy commitment and implementation on gender equality in the country's agricultural sector
- Inadequate guidance in the implementation of the agriculture regulatory framework partly causes unintended outcomes.
- Most interventions by the government and private sector focus primarily on technical aspects while ignoring social aspects including gender.
- Applying gender transformative approaches (GTA) will facilitate the achievement of gender equality and realisation of other targets in the agricultural sector.

Background

Gender is a cross-cutting issue that requires mainstreaming in agricultural policies, strategies, programmes, and actions. Considering it as a cross-cutting issue, most policy documents place gender towards the end of the policy documents (see Table 1 for more information). Unfortunately, most of the policy-makers either consciously or unconsciously seem to equate placing gender towards the end of the policy documents with ancillary issues. Consequently, gender lacks detailed contextualisation, analysis, and concrete options in most policy documents. Most policies argue that gender is cross-cutting and some policies such as agricultural marketing policy (URT, 2008) contend that gender is dealt with in the national gender policy. Such a position may present a myth, risks limited analysis and coverage in agricultural policies, and signals limited buy-in on gender issues in respective policies. The way national policies and strategies treat gender translates into local sub-national policies, programmes, and projects. Consistently, most projects, programmes, and interventions at the grassroots level ignore or slackly consider gender, hence the unintended social outcomes and persistent gender inequality. Failure to raise this fact may maintain the business as usual attitude, often to the disadvantage of women, who account for the majority of agricultural labour force in Tanzania.

This policy brief reports the findings based on the documentary reviews and fieldwork conducted in Kyela, Tanzania, as part of ongoing PhD research project at the of Dar es Salaam on *Transforming rice sector and gender practices in rice farming, processing, and trading in Tanzania*.

Findings

Gender is a cross-cutting issue

The Tanzania Women and Gender Development Policy treats gender as a cross-cutting issue. Thus, it requires sectoral policies, strategies, programs to mainstream gender. Consistently, the country's agricultural regulatory framework either explicitly or implicitly consider gender as cross-cutting issue (see Table 1). Yet, these policy guidelines mostly do not integrate gender across the policy documents put it as one of the cross-cutting issues, often towards the end of policy documents. The National Rice Development Strategy II is a good attempt at mainstreaming gender in the agricultural regulatory framework. Other policies such as the Agricultural Marketing Policy (URT, 2008) argue that gender is dealt with in the gender policy. As such, they include limited separate content on gender, hence giving it superficial treatment. In fact, the phrase 'cross-cutting' is either taken for granted or not well guided. Significantly, the national gender policy does not address gender in agriculture. It is alarming when the sector's specific policies, strategies, and programmes consistently include gender as a cross-cutting issue rather than mainstream it. Consequently, projects and actions at implementation level lack guidance

and seem to treat gender as cross-cutting too. It is important to define how cross-cutting gender is in agriculture and what that means in practice. Rather than mainstream gender in conventional agricultural policy and strategic documents, a standalone agriculture gender policy or strategy may be crafted. Nigeria's agriculture gender policy and Rwanda's agriculture gender strategy are good examples of gender regulatory frameworks in agriculture. Nigeria developed its gender policy in agriculture with the support of Consortium of International Agricultural Research Centres (CGIAR). The two countries present lessons from which Tanzania can draw in effectively integrating gender in the agricultural sector.

Table 1: Gender in selected national and agricultural policy documents

Policy/ strategy document	Gender inclusion	Main message	Remarks
National Agricultural Policy(NAP) 2013	Gender is a cross-cutting issue (URT, 2013: 29)	• Aims for equitable share and participation of women and men in agriculture • Sets to promote labour saving technologies to women • Sensitises the community to get rid of inappropriate practices and beliefs • Promotes farmer groups for the growth of rural entrepreneurship, especially among women	Treats gender-based constraints as an ancillary challenge to agriculture in Tanzania, thereby missing the depth of analysis accompanying other 'core' challenges
Agricultural Sector Development Strategy (ASDS II)	Gender is implied in cross-cutting issues (balanced and equitable participation of women and men)	• Ensures balanced and equitable participation of women and men in agricultural development • Continues to improve extension methodologies including gender mainstreaming • Women's participation in modernisation of agriculture is one of considerations in selecting priorities	Gender is not mentioned in strategic thematic areas
Agricultural Marketing Policy(AMP) 2008	Gender is a cross-cutting issue (URT, 2008:21)	• Women's participation in crop marketing is constrained by social and traditional factors • Promi9ses to mainstream gender in all agricultural marketing related interventions	Argues that gender is dealt with in the national gender policy; No implementation plan to mainstream gender in agricultural marketing
Agricultural Sector Development Programme Phase Two (ASDP II)	Gender is a cross-cutting issue (URT, 2016:116)	• Emphasises adequate inclusion of women in all stages of agricultural interventions in the agricultural sector including designing, implementation, and evaluation	Gender-based constraints lack rigorous analysis (URT,2016:22)
National Rice Development Strategy (NRDS) II	Mainstreamed throughout the document (not addressed on its own)	• Women's engagement in rice farming is characterised by excessive workload including farm and housework, and limited access to resources and appropriate technologies • Promises to ensure that mechanisation technologies include the less privileged groups such as women	-NRDS II offers more detailed and specific intervention for women in each policy proposition -Yet, gender-specific analysis is missing

Equating gender with women

Most policy documents use women and gender interchangeably. They often consider the presence of women as a good indicator of gender equality. However, this is insufficient and misleading. For example, women account for 55% of the agricultural labour in Tanzania but account for 15% of landholders, earn 43% of what men earn, and rarely feature in irrigation farming. Thus, core issue is not women's participation; it is the power relations between women and men, which determine participation and benefits of each gender group in the agricultural sector (cf. Ilomo et al., 2021). Such a view requires noting the enabling and constraining factors. Kyela presents a good example in better understanding of gender inequalities in agriculture. Women account for most traders in the district but they are presented as not pro-technology; dominate in small and informal businesses because of limited access to resources; their interaction with men customers is closely monitored and often equated with intimacy; and participation beyond the district borders is restricted by their husbands. All these aspects reflect gender relations that need addressing in the policy. Therefore, gender extends beyond the number of women in agricultural sector.

Table 2: Critical reflections on selected issues in the rice sector in Kyela, Tanzania

Issue	Extended description	Critical reflections
Establishment of new marketplace and introduction of modern technology	-Established new marketplace at Kikusya -The marketplace accommodates two high-tech processing facilities (1 for the government, 1 for a private investor) -The government processing facility is fenced -Rice trading is mainly done within the processing facilities	-Men traders control the marketing of rice in the marketplace -Access to the market is somehow controlled -Fewer women players because of enhanced automation of rice processing -Gender was possibly underrated in the design and implementation of the project
Enforcement of the use of weight technology in rice business	-Weight technology is expected to replace the volume measures that are historical in the Kyela rice business -Both weight technology and volume measures are used in rice business in the district -Volume measures are still predominant in rural Kyela	-Rice business include micro, small, and medium firms -Women account for most rice traders (mostly in micro and small businesses) -Norms favour men in terms of access to resources to acquire weight technology -Strict enforcement of the law may expel women from the rice business

The institutional set-up: One ministry sets the policy, the other implements it

The Ministry of Agriculture, as part of the central government, formulates the policy whereas regions and districts, as part of the Local Government regime, implement it. The districts and regional government report on the implementation of the policies to the Ministry of Agriculture. Regional and districts agricultural officers and extension officers are, however, primarily answerable to the regional and district governments, which may have other priorities rather than gender per se in agriculture. Since policy documents neither treat gender as a core issue nor mainstream it, implementers seem to focus on meeting the

targets in core areas, for example value addition in rice (see Table 2 and Box 1). As a result, gender consideration misses out in some of these agricultural interventions. Waiting for reports to note gaps in the implementation of the policy prolongs the time to achieve gender equality. Policy implementation would be effective if the set-up would place policy-makers and implementers in the same ministry, in this case, the Ministry of Agriculture, which should include agricultural and gender experts.

Box 1: Introduction of innovative technology and new marketplace

To boost value addition in the rice sector and take the market closer to the farmers, the Kyela local government installed a high-tech rice milling and grading facility at Kikusya, a former village, which is about 3km from Kyela town. Later, a retired civil servant originally from Kyela installed a more sophisticated technology as a way of giving back to the community. Eventually, two processing facilities at Kikusya processing centre or marketplace emerged. After unimpressive performance, the district government delegated the supervision of its processing facility to the village, whereby village residents consciously or unconsciously selected men to supervise the facility on their behalf.

The state-of-art rice milling technology installed in the district has enhanced the value of Kyela rice and revived its image, which started deteriorating. Most of the farmers from Kikusya village now process rice for sale. Some traders buy rice from other processing facilities and take it to Kikusya for grading. During the peak business, Kikusya trades 6 tonnes per day, which is below the volume at the oldest and largest marketplace, Kalumbulu (at 75 tonnes per day). Yet, the Kikusya marketplace has tangible benefits for the rice sector in Kyela. It fetches higher prices than those found in other marketplaces of the district because Kikusya mainly trades in graded rice. Government officials, traders, and the farmers consider facilities at Kikusya as the model processing technology in Kyela.

Men traders account for most traders at the new marketplace, Kikusya. This marketplace does not include small retail traders. Women dry rice and support processing, through bagging and, sometimes, polishing rice. In all other major marketplaces such as Kalumbulu, Ipinda, Kasumulu and Ngyekye, women account for most rice traders, including wholesalers and retailers. The few women trading at the Kikusya marketplace, often buy rice from farmers, process, and sell it to men agents at the market. They rarely have direct access to large traders from outside the district, region, or country. Some large traders who originally bought rice from Kalumbulu marketplace are now buying rice at Kikusya, because it trades in graded and quality rice for middle- and high-income classes.

Recommendations

Some policy-makers and scholars no longer consider gender as an issue. According to some of them, gender-equality is either already achieved or gender differences are worth maintaining (Broadbridge & Simpson, 2011). Such assumptions seem unrealistic and problematic. As the documentary review and evidence from Kyela district show, gender inequality is an unfinished business that is worth exploring and addressing. With that in mind, and recognising the country's commitment to achieving gender equality, we recommend several measures that may contribute to addressing the existing gender inequalities in agricultural sector in Tanzania:

- The Ministry of Agriculture in collaboration with other MDAs need to provide a better guidance in mainstreaming gender in the agricultural sector. This should include clarifying what cross-cutting means in the context of agriculture, and mainstreaming gender in the agricultural regulatory framework and in the implementation of the policies.
- The National Agriculture Policy, strategies, and regulations must consider and incorporate gender relations as these aspects underscore the root-causes of gender inequality. Doing so would address the fact that gender goes beyond women and men.
- The Ministry of Agriculture in collaboration with the Ministry responsible for gender should establish the agriculture gender policy and strategy, which will be implemented in their own right to create the expected social and economic impact. Nigeria and Rwanda present some lessons on crafting gender specific policy and strategy in agriculture.
- Designers and implementers of agricultural specific projects or programmes including LGAs must consider both gender and technical aspects of the projects to deliver the expected and just results. They can learn from approaches such as gender transformative approach with a track-record, especially in Asia (Kantor et al., 2015).

It is possible to end the gender inequalities in agriculture, at best in the long-term. However, doing so requires a major shift in the way the government frames policy statements on gender, implementers translate them into actions, and having a clear and logical institutional framework that supports and ensures the effective implementation of the policy. Overall, gender is not ancillary but a core aspect in the agricultural sector, where most of the labour force are women.

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Promoting Women's Participation in Rural Entrepreneurship through Women's Groups

By

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Key Message

1. Rural entrepreneurship for women small-scale producers in Tanzania has the potential of contributing to sustainable agricultural development and poverty reduction.
2. Though rural women's self-help groups are the driving force for their engagement in rural entrepreneurship in the rice sector, their impact is low under the current policy framework.
3. Despite the potential of rural women's self-help groups in promoting their engagement in rural entrepreneurship, these institutions face the challenge of dilapidated infrastructure, small populations leading to small transaction sizes, and risky returns in rural areas with concentrated farms.
4. The government has introduced several ongoing preferential treatments at the policy level to support the active participation of specific groups in public procurement; however, women's groups in rural areas are largely excluded.

Background

This policy brief presents policy recommendations based on field research and review of various documents. The field research was conducted in the rural districts of Kahama and Shinyanga in Tanzania as part of the PhD research project at the University of Dar es Salaam entitled *Navigating context-related barriers for women's engagement in rural entrepreneurship through groups in the rice sub-sector*.

Women's participation in entrepreneurship is on the rise and contributes significantly to the global economy (Sajjad, Kaleem, Chani, & Ahmed, 2020). An estimated 163 million women run businesses in 74 economies, with an overall increase of 10% in women's entrepreneurial activity between 2014 and 2016 (MIWE, 2018). Tanzania is no exception, as women are the main economic actors. However, this progress does not apply equally to all women due to context-specific barriers women entrepreneurs from rural Tanzania face. Indeed, rural women continue to face widespread context related barriers, embodied in the laws that prevent them from owning their own businesses by limiting their access to land, credit, or control over marital property. Moreover, due to the unequal distribution of social roles between men and women, rural women are restricted in their mobility and have too little time at their disposal (Langevang, Hansen, & Rutashobya, 2018). These practices negatively affect their engagement in agribusiness entrepreneurship in rural areas.

Nevertheless, agriculture remains an important sector of the economy, providing livelihoods for most of Tanzania's rural population, especially women. According to the Ministry of Finance and Planning (MoFP) Five-Year Development Plan (FYDP) 2016/17-2020/21, the sector contributes 30% of exports and 65% of intermediate inputs to the industrial sector. This contribution is the largest and surpasses those of all other sectors. In addition, the sector contributes significantly to food supply in Tanzania (Wineman, Jayne, Isinika Modamba, & Kray, 2020). In other words, agriculture plays a critical role in economic growth and can be directly linked to sustainable development and poverty alleviation, especially in rural areas if stakeholders are given their incentives equally (Komatsu, Malapit, & Balagamwala, 2019)women's involvement in the agricultural cropping production process could increase their work load and reduce their BMI. Using three waves of the Tanzania National Panel Survey, we investigate the extent to which time spent in agricultural crop production affects women and men's nutritional status among non-overweight individuals (age 20-65. Since most of the rural dwellers are women, their engagement in rural entrepreneurship is crucial.

Why is action needed?

The findings from our study indicate that rural entrepreneurship for women small-scale producers in Tanzania has the potential of contributing to sustainable agricultural development and poverty reduction. However, if the status quo is maintained, very few women will participate in rural entrepreneurship. It is, therefore, important to identify the key drivers of inclusive agricultural entrepreneurship and the basic requirements for its achievement.

Looking at rural entrepreneurship alone as a key development factor will not lead to significant development and promotion of rural enterprises, especially among rural women. What is additionally needed is an enabling environment that stimulates rural entrepreneurship. The existence of such an environment depends largely on the existence and implementation of conducive policies to support rural women. The effectiveness of such policies,

in turn, depends on understanding women's engagement and the context in which entrepreneurship takes place. Context plays a pivotal role in the flourishing of rural entrepreneurship and, therefore, policies are needed to accelerate the process.

Based on the results of our study, this policy brief, thus, addresses two questions. First, it answers the question of why the promotion of women's groups in the context of rural entrepreneurship is a force for economic change and, second, the policies recommended to create an environment in rural areas where women's groups thrive and enable meaningful engagement of women in rural entrepreneurship.

Promoting women's groups in rural entrepreneurship

In low-income countries, groups, also known as collective actions or co-operatives, help to empower disadvantaged groups such as women (Gramzow, Batt, Afari-Sefa, Petrick, & Roothaert, 2018)registered farmer organizations and contract farming arrangements have been very common approaches that have been used to integrate smallholder farmers into agricultural value chains. This study compares a farmer-based organization and a contract farming approach, both of which are active in the same geographic location and operate under the same economic and social constraints. While concentrating our analysis on four critical factors (group homogeneity, size and ability to cope with "free-riding" behavior; supplier-buyer contract enforcement; access to external services; and the supportive role of the government and NGOs who are engaged in agriculture. In areas where the private or public sector is weak, especially in remote rural areas, groups enable local people to organise and improve their situation (Chaddad & Cook, 2004). In Tanzania, grouping initiatives have promoted the formation of some credit schemes such as savings and credit co-operative societies (SACCOS), Agricultural Marketing Co-operatives (AMCOS), Village Savings and Loan Associations (VSLAS) and self-help groups.

However, findings from our study in Kahama and Shinyanga rural districts have shown that for most women in rural areas, these initiatives are inaccessible and difficult to fulfil and/or do not share the same goals in addressing women-specific barriers to rural. As indicated in Table 1, unlike other forms of groupings, self-help groups seem to hold promise in creating space for rural women's engagement in rural entrepreneurship.

Table 1: Collective action initiatives in Tanzania, roles and their availability to rural women

SN	Forms of Collective Action Initiatives	Roles and services provided	Availability and opportunity for rural women
1.	Savings and Credit Co-operative Societies (SACCOS)	Providing finance services to its members	- Cultural norms restrict rural women to access them - Men are more likely to access them due to the assumption of being the bread-winners
2.	Agricultural Marketing Co-operatives (AMCOS)	Production and marketing of agricultural products	- Limited in number and mostly accessed by men - Requires access to land and rural women usually do not own land - Most of the rural women cannot afford renting land for production
3.	Village Savings and Loan Associations (VSLAS)	Savings, credit and in some cases, insurance in groups	- Individually women vary in ability and experience with savings - Not appropriate for most rural women to engage in rural entrepreneurship
4.	Self-help Groups (SHGs)	Saving, credit, insurance and group entrepreneurship	- They are readily accessible to rural women - Mutual support, where members help each other - They can serve many different purposes depending on circumstances and needs - Very supportive of rural women in entrepreneurship

Despite the potential of women's self-help groups in promoting their engagement in rural entrepreneurship, our study findings have indicated that these institutions face the challenge of dilapidated infrastructure, small populations hence leading to small transaction sizes, and risky returns in rural areas with concentrated farms. This reality calls for policy intervention to improve the situation. The next section recommends policy options aimed to support women's self-help groups to drive rural entrepreneurship and, thus, rural development.

Recommended policy options necessary for unshackling women groups' engagement in rural entrepreneurship

Extant literature already contains many examples of successful rural entrepreneurship. Behind each of the success stories of rural entrepreneurship, there is usually some kind of institutional support. From documentary review, it is evident that the government is working hard to develop some policies aimed to support among others women's groups engaged in entrepreneurship activities. For instance, the recent revision of the Public Procurement Act stipulates that procuring entities should allocate at least 30% of the procurement budget to special groups (Section 64 (2) (c) of the Public Procurement Act (PPA) Cap 410 (as amended in 2016) and Regulation 30C of the Public Procurement Regulations (PPR) of 2013 (as amended in 2016). However, special groups in urban areas mainly feel the impact of this policy option compared to their rural counterparts.

The findings of our study have highlighted several challenges women's groups engaged in rural entrepreneurship in the rice sector experience. Table 2 summarises these challenges and

the recommended policy options in addition to indicating the actors responsible for such envisaged change:

Challenge	Policy option	Actors
Poor state of rural infrastructure (district access roads, electricity supply, public storage and processing facilities, among others)	- Maintenance and rehabilitation of rural roads - Speeding up the rate of rural electrification - Construction of public storage and installation of paddy processing factories	- TARURA, DED's office - Ministry of Energy and Minerals through REA - PPP under BOT programmes (DED's office, private sector and SIDO)
Small size of the markets	- Accelerating demands at the local, regional and national levels.	- LGAs under DED's office and should source rice and other needed commodities from women's groups - Each ward should have a permanent desk for the co-operative development officer to co-ordinate groups and link them with LGAs
Lack of agribusiness associations to support rural women's initiatives through groups	- Delineate functions and extend their services to remote rural areas	- LGAs through departments of community development and co-operatives, MVIWATA and ACT

How do we achieve sustainability of the proposed policy interventions?

An effective rural women's entrepreneurship policy requires not only the development of local entrepreneurial skills, but also a coherent regional/local strategy. Evidence shows that where this is the case entrepreneurship plays an important role in fostering economic, social and community development in rural areas. The top-down approach gains effectiveness when it is tailored to the local environment it is designed to support. The other condition for success is that ownership of the initiative remains in the hands of local community members. Regional development agencies that meet both criteria can also make an important contribution to rural development through entrepreneurship.

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Increasing Women's Participation in Horticulture Export Business in Tanzania: Constraints and Policy Options

By

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Key Messages

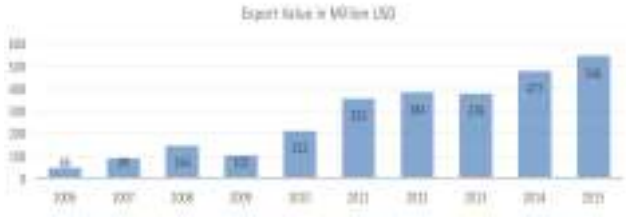
- Horticulture export business offers a large and expanding market currently dominated by men.
- Within the horticulture export value chain, women are found mostly in the picking, sorting and packing as they are considered more suitable for managing delicate horticultural crops, and not in the business part of the chain.
- Agricultural policy shift is required to actively support women's participation in agribusiness, particularly the horticulture export business as it marks one of the few opportunities for women smallholders farmers to break out of the poverty crust.
- Targeted policy support is required to:
    - Lessen women's household burdens to have ample time to productive activities;
    - Construct easily accessible facilities; and
    - Disseminate knowledge on Global Good Agricultural Practices (Global-GAP).

Overview

Tanzania's horticulture sub-sector encompasses the production and processing of flowers, fruits, vegetables, seeds, spices, and roots and tubers (Estrada-flores, 2019). In the aftermath of economic liberalisation coupled with the opening up for foreign and private investment, thousands of jobs have been created in the horticulture sub-sector, mostly in farms and pack houses (De Blasis, 2020). The reports available show that, in 2015, the sub-sector contributed 38% of the foreign income earned from the agriculture sector, with an exports value, which reached the US dollar 545 million (MMA, 2017) whereas in 2016, horticulture exports was valued at US dollar 591 million (FAO 2011). This sub-sector employs about 2.5 million people, which makes it a major employer within the agricultural sector (MMA, 2017).

The horticulture sub-sector has now become one of the important and promising sources of economic growth and human development in Tanzania (MMA, 2017; NBS, 2020). Its growth rate makes it to be one of the fastest growing sub-sectors of the economy with much potential that has yet to be fully exploited. This growth is explained by the increase in the production of fruit and vegetables in Tanzania, and growth of horticultural products sale volume and value in both domestic and export markets (TAHA 2016).

Based on the data on export trends available as Figure 1 illustrates, TAHA projected that by 2020, horticultural export value would have grown to US dollar 1,850 million due to increasing investments in the sector (MMA 2017). Likewise, Euromonitor International (2018) reported that, by 2022, the global demand for fresh fruit is expected to reach 600 million tonnes, while the demand for vegetables will reach 850 million tonnes. This potential growth places horticulture as a genuine opportunity of income diversification in the agricultural sector. Despite the tremendous COVID-19 effects, prospects for horticultural products remain highly promising.



Source: MMA (2017)

Figure1: Tanzania Horticulture Export Value 2006 - 2015

Generally, the horticulture sub-sector in Tanzania has a promising future and potential to become a strong industry. In fact, it is one of the most important sub-sectors in the agricultural economy, and needs serious attention for the country to realise the benefits. The sub-sector provides ideal opportunities to smallholder farmers to increase their earnings and help alleviate poverty, as well as achieving the development goals set by the government.

Women's constrained participation in the expanding horticulture export business

Studies show that most of the workers in the horticulture sub-sector are women. However, women are found mostly in small farming, picking, sorting and packing, as they are considered more suitable for handling delicate horticultural crops, and not in the business part of the chain (De Blasis, 2020; Estrada-flores, 2019). Yet women's participation in horticulture value-adding and export business remained low, particularly in marketing related activities (De Blasis, 2020). The few women in business are mostly found in local village markets, where there is low choice of products with unreliable supply (Visser, 2015).

To seize opportunities in the horticulture sub-sector, rural women must invest, upgrade and expand their activities. To do so, they need active and targeted support that addresses the gendered constraints that hinder women's participation. This policy brief, therefore, reports the findings on women's constrained participation in the horticulture export business and suggests policy options for increasing women's participation. The report uses empirical materials from the fieldwork conducted in Lushoto district, with the support of secondary data from various publications related to this topic.

Women's gendered constraints:

Women have less time to spend on business activities

Since the exported horticultural products need to meet the Global-GAP, the export business requires more time, commitment and resources compared to traditional cash and food crops. However, the dominant patriarchal system allocates most of the household activities to women, leaving them with less time to spend on business related activities. At the most, the women feature prominently in subsistence farming, raising children, taking care of the old and sick relatives as well as taking care of household chores (Sachs, 2018). On the other hand, men spend more of their daily time in business-related activities. Generally, the labour burden of women exceeds that of men, and includes a higher proportion of unpaid household responsibilities (FAO, 2011; Kitembe, Mrema, Masaki, Luande, & Mkina, 2017).

Lack of knowledge

Most of women, especially in rural areas have low level of education and lack knowledge on good agricultural practices, hence limited to subsistence farming. The perishable nature of horticultural products and high Sanitary and Phytosanitary Standards (SPS) require technical ability and quality control that most of women lack. The demand for horticultural export business requires women to keep pace with developments in the industry, as currently few women can afford given the structural challenges. In fact, most of the women in this sub-sector rely on their own ingenuity, hard-work and creativity to succeed.

Gender immobility challenges

Lack of facilities established nearby for collecting, cooling and sorting makes it increasingly difficult for women to engage in cultivating export-oriented horticulture products. For women, spending more time on travelling implies less time for leisure and housework, which may cause family conflicts (returning home late or failure to manage house chores).

Unreliable export contracts

For the few women who have dared to engage in the exportation value chain, they still suffer from unreliable farming contracts for export-oriented horticultural products. Due to lack of knowledge on the legal terms and technical languages used in the contracts, most women operate under trust bases. Oftentimes, they end up suffering from the loss resulting from high rejection rates and breach of contracts by buying agents.

Land ownership

As part of the key resources to facilitate the women's engagement in agriculture and agriculture-related business, women need to own (or at least be able to rent) enough land. Yet, land ownership is a major constraint for women engaging in agricultural- related business activities. Indeed, women, especially in rural areas still face challenges when it comes to land and property ownership primarily because of patriarchal norms and values. Mostly, the land used for cultivation by women is marginal and always used for food crops intended for immediate consumption by the household.

Limited capital and access to financial services

Women have limited access to credit and financial services because they have no land or property to serve as collateral. In some cases, collateral is not the problem but getting consent from the husband to take a loan using a family property as a collateral is the problem.

Conclusion

Promoting women's participation in horticulture export businesses can significantly benefit the country in the following ways. Firstly, since most of the agricultural activities occur in rural areas, horticultural production creates employment opportunities for the rural poor, notably women, and has significant impact on poverty reduction, food security and community wellbeing. Secondly, horticulture forms an important source of more diversified and higher value non-traditional exports. Since women constitute the majority in the agriculture sector, enhancing their full participation would result in increased yield of the sub-sector's potential. Thirdly, the income earned by women might also result in increased decision-making power in the household and increased women's empowerment with other spill-over effects such as increased (girl) child schooling and a reduction in early marriages.

Despite the promises camouflaged in women's participation in the horticulture export business, without supportive policies in place, success is often hard won. Through supportive policies that address the imbalances in horticulture export business, Tanzania will reap the economic rewards that result from the full participation of women in the horticulture sub-sector.

Policy recommendations

From passivity to active women-specific support

Gender mainstreaming approach to social policies would assist in designing supporting structures aimed to reduce the women's burden in the community and create more time for women to engage in business-related activities. One practical solution may include the government through the Ministry of Education, to design public childcare supporting systems such as government-run kindergartens and baby-care centres in villages to reduce the time that women spend on taking care of the children.

Bringing facilities closer

The government should bring closer to the producers all the necessary facilities required for the production and exportation of horticultural produces. In this regard, the Ministry of Agriculture in collaboration with other stakeholders such as TAHA should prioritise and construct facilities such as cold-rooms for sorting, storing and packaging within a relatively shorter distance from where the horticultural produces are cultivated.

Provision of access to technical knowledge and advice for upgrading

Continuous upgrading is key to competitiveness. Since women are the most disadvantaged group when it comes to technical know-how, the government should extend the functions of the agricultural extension offices to include the responsibilities to identify the key technical skills women require in the horticulture business and design the mechanism of delivering the required skills. For instance, the government, through their training institutions such as VETA, may design subsidies sector- specific training programs for women to enhance their capacity to engage.

Support technical skills upgrading by increasing research activities

Government should build research capacity and allocate ample budget for adequate research and extension services to upgrade the agriculture sector towards market demand targeting women in the horticulture business. Traditional methods of production, harvesting, storage and handling, not only affect production but also do not comply with sanitary and other health requirements. Research on production of horticultural produce, which have a competitive advantage as a niche market should be explored. Also, the dissemination of research information should reach the rural areas, including skills on compliance with health and environmental requirements, including sanitary and phytosanitary requirements.

Laws and regulations guiding the export contracts

There should be in place clear and specific laws and regulations that guide export contracts to avoid the exploitation of women by tricky and shady business partners. These laws should also be made known to women and the government should make legal aid and facilities reachable and accessible for women, particularly in the rural areas.

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Sub-Theme 2:

Food Security

Airflow Onion Storage Technology for Reducing Post-Harvest Losses, Improving Farmers' income and Enhancing Food Security in Tanzania

By

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Introduction

Onion production is an important agricultural activity in Tanzania since it contributes to the household as well as national income. In Tanzania, onion is one of the most important spice vegetables, whose annual production is estimated at 228,800 metric tonnes, an equivalent of 1.8% of the annual production on the African continent (FAO, 2016).

Despite the significant quantity of bulb onion production in Tanzania, the post-harvest losses (PHLs) pose a significant threat and is estimated to range between 30% and 40% (Katinoja *et al.,* 2011) in many developing countries. Various publications demonstrate that farmers in Tanzania lose up to 40% of the harvest through PHLs and even higher for high perishable crops including fruits, vegetables, roots and tubers (NAP, 2013; NPHMS, 2019). Such PHLs have a negative impact on farmers, as they affect their income, livelihoods and production incentives.

Significant losses in quantity and quality of bulbs onion occur during storage. Consultative meetings with onion farmers in Singida region indicated that, due to the unavailability of effective storage technologies, the bulb onions are traditionally stored in sacks spilled onto a raised platform for the maximum storage of 3 - 7 days. Consequently, the farmers are compelled to sell the onions at a lower price.

The Study and Findings: The study on bulb onion storage technology was conducted in Singida region, Singida district at Minyaa village by a master's student (Eliah Ayubu) from The University of Dar es Salaam (UDSM) under the supervision of Dr. Aloyce Hepelwa and Dr. Oscar Kibazohi.

Discarded onions at Singida market

Methodology:

Experimental Investigation: The study aimed to understand and innovate the most effective ways of reducing post-harvest storage losses and prolong the shelf-life of bulb onions in Tanzania. The study involved constructing an improved storage technology termed as ***"Airflow Onion Storage Technology, (AOST)."*** The study tested technical the effectiveness of the AOST vis-à-vis traditional storage methods and assessed the technology cost-benefits.

Onions were initially stored for three (3) months (March-June, 2020) and for another three (3) months (June-September, 2020) to achieve a cumulative six (6) months storage duration. The study involved 50 selected smallholder farmers from the study location, who were trained on post-harvest management before participating in the whole study process.

Findings: The performance of AOST was measured using two major components: Technical effectiveness and Cost-Benefit Analysis.

Constructing AOST for the study intervention

Farmers' Training and Discussion Sessions

Technical Effectiveness: In this component, three key variables were observed—(1) Loss of Weight (%), (2) Sprouting (%), and (3) Rotting (%). These parameters were monitored in an interval of 10 days over the three-month storage duration.

The results show that total onion loss was 11.9 percent of the total initial stock. Specifically, 9.4 percent of loss was observed in weight; 1.3 percent of the loss was observed in the sprout parameter; and 1.2 percent was observed in the rotting parameter. Literature indicates a maximum loss of 13% for AOST. In comparison to the survey results, the AOST is technically effective in reducing post-harvest loss from 30% - 40% to 11.9%, hence enhancing food security and increasing income generation from the onion business.

Cost-Benefit Analysis: The results indicate that, the investment of AOST is economically viable with a positive Net Present Value (NPV) of 1,184,574; Benefit Cost Ratio (BCR) of 1.7 and Internal Rate of Return (IRR) of 44%.

Key Messages

- Perishable crops sub-sector growth including bulb onion is highly constrained by higher magnitude of Post-harvest Losses (PHL) at various stages of the value chain.
- Invention of effective, affordable and economic Post-harvest Technologies (PHTs) can lower the magnitude and effects of PHLs in Tanzania.
- Airflow onion storage technology reduces PHL and is an appropriate technology for onion farmers.
- Policies to reverse losses exist; they require "joined up" government action in supporting technological innovations, technological adoptions, trade policies, and targeted businesses, and active government collaboration with academia for fostering studies on post-harvest losses in the value chain.

Policy Recommendations And Statements

Onion production is potential for both farmers and the government as it contributes to the growth of individual and national income. To reduce onion losses during storage, unprecedented efforts and strategies among the key chain actors including farmers, the private sector, development partners, academic institutions and the government are required to create a policy framework for rendering active support to reduce PHL reduction and enhance food storage and prevent its wastage.

1. The Government in collaboration with higher learning institutions (e.g. the UDSM) should strengthen awareness creation, capacity-building and information dissemination among onion farmers and other actors in post-harvest handling, use and adoption of effective storage technologies through:
   - Workshops, seminars, farmers' field schools, publications, TV and radio campaigns, and online platform.
   - Constructing technology demonstrations units in different onion producing areas in the country.
2. The Government in collaboration with higher learning institutions (e.g. the UDSM) should upgrade and strengthen skills of agricultural extension officers at all levels to enhance the provisions of competent extension services in reducing the magnitude of onion PHLs.
3. The Government should influence smallholder onion producers and other actors through LGAs and village governments to participate in various research activities conducted in their localities to gain new and up-to-date skills and knowledge on onion production and storage technologies.
4. The Government, higher learning institutions (e.g. the UDSM), development partners (SIDA) and other stakeholders should support scaling AOST up by funding further research for testing the technology in different localities for adaptation and commercialising its application in addition to funding more such research on innovative modern PHTs.
5. The Government through local government authorities, ministries and other parastatal entities should create a conducive and incentivised environment for curbing post-harvest losses by facilitating access to finance among farmers to raise their capital for investing in storage technology construction and/or installations, hence facilitating technological adoption.
6. The Government through respective ministries and LGAs should support the commercialising of AOST installations at onion markets and help traders to prolong the onions' shelf-life and reduce PHLs.

Conclusion

Modern and improved PHTs, e.g. AOST, mechanisation, have proven to be more effective than traditional measures in curbing PHLs. Therefore, PHL reduction is possible by building on the success attained. Key policy changes such as a supporting technological innovation and fostering adoption could re-establish confidence in improving storage of agricultural crops, especially perishable crops, in Tanzania, and generate new stability and enhanced profitability in the agricultural sector.

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The Linkage between Forests and Household Food Security: Empirical Evidence From Shinyanga, Tanzania

By

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Introduction

Even with economic and agricultural advancement, many rural households in developing countries still depend on forests for their livelihoods and food security (Ali and Rahut, 2018; Angelsen et al., 2014). Generally, forests are more important to rural poor than to the non-poor households, since the latter have more options for sustaining their livelihoods than the former (Wunder et al., 2014). A large segment of poor households in rural areas derive benefits from forests for their daily subsistence and survival, as well as for distributing income and reducing poverty (Fonta et al., 2011). Forests have three potentially distinctive roles in supporting rural livelihoods: They can function as a safety net, supporting livelihoods in times of shocks to other income; they can support daily consumption needs as a coping strategy; and they can help reduce poverty by enabling a sustainably higher household income (see e.g., Angelsen and Wunder, 2003).

These livelihood benefits notwithstanding, many forest-dependent households in rural settings remain poor and, therefore, exposed to food insecurity (FAO, 2011). Several authors have raised their concern that, in practice, forests may be poverty traps. Forest activities provide many rural households with relatively low returns on their labour, such as collecting non-timber forest products—NTFP (Angelsen and Wunder, 2003). Poor households are obliged to rely on such low-return activities as a last resort because they lack other income-earning opportunities (Angelsen and Wunder, 2003). Faced with this bleak outlook, rural household incomes remain low, which has long-term negative consequences for their livelihoods and food security. Other studies (e.g., Ali and Rahut, 2018), however, found that participation in forest-based livelihood activities impacted on rural household income positively and helped to reduce poverty. For example, Rahut et al. (2015) in a study on household participation in community forest management programmes in Bhutan found that households participating in such programmes had higher levels of income, lower poverty levels and greater food security than their non-participating counterparts. On the other hand, Abadi's (2017) study in Ethiopia found that forests did offer some safety, but those who participated in forest resource extraction were relatively poor, and had worse off food-security outcomes than those who did not rely on forests. The study recommended embracing alternative livelihood strategies and social protection programmes to solve the problems of food insecurity and forest degradation much more effectively.

This apparent contradiction regarding the impact of forests on the rural poor and their food security motivated the current study to determine the relationship between poor rural households and forest use and to establish the link between forests and household food security. The use of policy-relevant knowledge and data on the contributions of forests to food security are important for improved food security in Tanzania and other developing countries (FAO and MNRT, 2020). For any appropriate forest-related policy or programme to work, however, there first needs to be an understanding of the socio-economic characteristics of, and forest utilisation by, the households concerned (Pandey, 2010). Given the existing scant data on forests and food security in Tanzania (FAO and MNRT, 2020), this study seeks to answer the following questions: Do participants and non-participants differ socio-economically? What are the determinants of participation in forest activities? And what are the differences between participants and non-participants in forest activities in respect of food-security outcomes? These questions are also significant for forest policy formulation because food security at the household level necessarily includes a careful examination of the livelihoods of forest-dependent households. Thus, it is vital for forest policy approaches to be appropriately informed while factoring in such households.

Key messages

The empirical data for this study's analysis were obtained from rural areas in Shinyanga region in north-western Tanzania. The severity of poverty in Shinyanga is 3.2%,

which is worse than the 2.5% national average (Kilama, 2016 as calculated from 2011/12 Household Budget Survey and 2012 Census). Since poverty influences forest dependency and food security, this region made the criteria for conducting this study. The key findings were as follows:

- Though all the households in this study were farmers, some were additionally involved in economic activities related to forests. Participants in forest activities collected some of these forest products to sell them as a source of income for their daily subsistence.
- Some participants depended on collecting and extracting NTFP when they needed emergency cash during a crisis such as sudden death or illness of livestock, or loss of crops to pests and drought. For participants, the average forest income, expressed as a share of the sum income was found to be 23%; hence, forest income makes a fair contribution to their total income.
- Households with a member who had died or had fallen ill had a higher probability of participating in forest activities. Some of these households resorted to extracting forest resources to earn emergency cash by burning and selling charcoal, for example. Households also reported that it was quicker and easier to earn emergency cash by participating in forest activities than through other means.
- Households living further away from the forests had a lower probability of participating in forest activities than those near them. Comparable results were evident in previous studies, which found distance to the forest to be negatively related to participation in forest activities or to forest dependency.
- Household heads who engaged in off-farm activities—other than farming and forestry such as shop owners and employees in the public or private sector—were found to have a lower probability of participating in forest activities than those without such options. Moreover, off-farm income was reportedly higher on average than both farm- and forest-related earnings. Though engaging in off-farm activities could lead to earning higher incomes, as the study findings indicate, participants were averse to the risk of starting new ventures or shifting to alternative activities. For many of those who were dependent on rural forests, the start-up capital required for a new business such as a local shop was unaffordable. Furthermore, lack of a supportive infrastructure such as good roads, water and electricity that could encourage investment limited alternative sources of income. Consequently, these rural households remained largely dependent on forests for their subsistence, as a safety net, and as a way out of poverty.
- Regarding household food security, descriptive statistics show that, for the three consecutive years for which data were collected in 2018 (2015, 2016 and 2017), participants experienced more food shortages on average than non-participants did. This implies that, on average, participants were less food-secure than non-participants.
- For other food-security indicators, participants were again less food-secure and had lower levels of sufficient food than non-participants did. Compared with non-participants, respondents had fewer months of sufficient available food in the year preceding the interview. In addition, they experienced more days of having no food for the entire day in the seven days prior to the interview than non-participants did. Correspondingly, participants had a greater number of days of asking for food or relying on food from friends/relatives in the prior seven-day period than non-participants.

Overall, the empirical results suggest that participants who relied on forest for survival were less food secure than non-participants in line with the previous studies such as Abadi (2017). Indeed, despite the role forests play in fostering their livelihoods including food security, participants were nevertheless food insecure.

Recommendations

Thus, to reduce dependence on forests and poverty trap, households should be diversified with their means of obtaining an income. The government and private sectors through NGOs could collaborate to develop and improve socio- economic infrastructure like roads, water and healthcare facilities to attract investment into rural areas. However, such diversification can only be achieved by providing education and training to enhance unskilled or semi-skilled labour. Doing so should be coupled with the creation of alternative sources of income for rural households to engage in off-farm activities to earn cash. Such alternative earnings could reduce pressure exerted on forests through resource extraction and combat food insecurity because rural households would then have recourse to additional income sources.

The government in collaboration with the private sector can also aim to combat food insecurity by enhancing food storage facilities and farming methods that increase food production. Most rural forest dependent households used traditional granaries that were ineffective in preventing food damage. This challenge could be encountered by providing subsidies to build or buy efficient storage facilities such as hermetic bags. To boost food production, there was also a need for improved farming implements, seeds, irrigation systems and information on good farming methods. As such, initiatives at the local government levels could be collaborative with the private sector through NGOs and donor funds from international organisations such as FAO and bilateral countries playing a crucial role in helping or continuing to provide aid and grants to the agricultural sector.

Conclusion

Although the rural household heads were all farmers, the survey found that most of them also participated in forest-based livelihood activities. This confirms that rural household farmers depend on such activities to survive, implying that there is a strong linkage between forests and household food security. There are three potential roles that forests are hypothesised to play in supporting rural livelihoods in developing countries: As a safety net, as a coping strategy, and as a source of poverty reduction. In Shinyanga, the first two emerged to be the most prevalent. Cutting across food-security outcomes, one sees that participants lacked sufficient food stocks as well as adequate income to support their food security. Implicitly, food security is a critical concern among forest-dependent rural households. This study also supports the stance that participation in forest activities leads to a poverty trap: Participants were less food-secure on average than non-participants. Since food security is important for rural households in Shinyanga in general, the region's forests need to be conserved to ensure continued well-being of the households that depend on them, since forests are linked to their food security.

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

By

Martin Julius Chegere and Monica Sebastian Kauky

Increased agricultural commercialisation is important, but it is not singly enough to improve household diet quality and child nutrition.

Introduction

The prevalence of malnutrition in Sub-Saharan Africa (SSA) is consistently higher relative to other regions of the world. The proportion of undernourished people in Sub-Saharan Africa declined from 30 percent in 2000-02 to 23 percent in 2014-16. Between 2000 and 2014, the number of stunted children increased from an estimated 50.1 million to 57.3 million in SSA. The Tanzania Demographic and Health Survey 2015-16 reports that about 34% of under-five children in the country are stunted, 14% are underweight, 5% suffer from acute and chronic malnutrition (wasting) and 4% are overweight.

Proper amount and variety of food are some of the important determinants of nutritional status. Thus, one way of addressing malnutrition is by consuming a high quality, diverse diet that provides adequate energy and nutrients needed for good health (Arimond and Ruel, 2000). Notwithstanding the importance of dietary diversity for good nutritional outcomes, the consumption of nutrient-rich foods is sensitive to changes in income levels and price shocks, especially for consumers with low incomes (FAO, 2013).

In fact, most of the agricultural households mix subsistence with market-oriented production (Jones et al., 2014). Producing for the market creates an avenue for using the revenue from crop sales to buy different foodstuffs in

markets rather than relying solely on own production. To optimise its earnings and consumption, a household can decide to sell agricultural products that fetch relatively higher market values and use the proceeds from the crop sale to buy diverse nutritious foods. However, if higher market value is associated with higher nutrition content and households consume less nutritious foods from their own production, without using the proceeds to supplement nutritious foods, then the nutritional level of the households become jeopardized. This study has examined empirically the linkages between agricultural marketing, household dietary diversity, and nutrition status in Tanzania to underline the important role agriculture plays through various channels in fostering nutrition.

Background

Despite a significant reduction in the number of underweight children and those suffering from chronic malnourishment in Tanzania between 1992 and 2015, the rates of stunting among children and disparities in nutritional status remain high. Regional disparities are wide ranging from 56% prevalence of stunting in Rukwa to 15% in Dar es Salaam in 2016. The nutrition status of a household is linked to agriculture through various routes: Production for household self-consumption; incomes from agricultural marketing; low food prices due to increased food supply; women empowerment; and agriculture contribution to national income and economic growth.

Agricultural marketing policies that foster agricultural commercialisation can be useful in enhancing efficiency in agriculture, increasing agricultural household income and, consequently, improving household food and nutrition security. In Tanzania, only 34 percent worth of the value of farmers' agricultural products is marketed. This low level of agricultural commercialisation may contribute to the farmers' low incomes. Low incomes affect the ability of farmers to spend on marketed diverse and nutritious diets. Moreover, agricultural marketing may be limited by poor supporting infrastructures. Thus, analysing the relationship between agricultural marketing, dietary diversity and nutrition status the household has an intuitive appeal.

Key messages

This study examined the effect of agricultural marketing on dietary diversity and its effect on child nutrition in Tanzania using three waves of the Tanzania National Panel Survey (TNPS) data (2008/09, 2010/11 and 2012/13). The study found statistically insignificant results on the effects of market orientation, as measured by commercialisation index and per capita value of agricultural sales, on diet quality (as measured by household dietary diversity score and food consumption score).

The effect of market orientation on dietary diversity (measured by household dietary diversity score and food consumption score), on the other hand, was found to be insignificant. However, when the analysis is dis-aggregated by income, market orientation had a positive and significant effect on dietary diversity among those in the lower income group but an insignificant effect on the higher income group. The study also found that per capita value of agricultural sales positively affected dietary diversity indirectly through the improvement of overall household income. When the commercialisation index is dis-aggregated into different agricultural-product components, the results obtained are mixed. Additionally, the study found an insignificant effect on diet diversity of marketing infrastructure, measured by distance to the nearest market, distance to the nearest major road and training, and extension services. On the other hand, the study found strong and significant effects of female education levels and overall income levels on diet diversity, which implies that improvements made in these factors can improve diet quality.

Further analysis shows that diet diversity has statistically significant simple correlations with lower probability of child stunting. When overall household income is controlled for the effect of dietary diversity on child

nutrition disappears. These results suggest that farmers tend to market crops with relatively higher nutritional content if they are associated with higher market value, and households end up consuming relatively less nutritious foods from their own-production activities.

Also, proceeds from agricultural sales are not spent on buying nutritious foods. Asa result, children's nutritional status suffered. The study also found the following factors to have positive and significant effect on dietary diversity: Belonging to a female-headed household, the age of the child, the education of the highest educated female in the household, and overall household expenditure.

Several implications emanate from these findings.

- First, improving on some factors, for example, female education levels and overall income levels may enhance dietary diversity.
- Second, some results seem to indicate that farmers tend to market crops with relatively higher nutritional content if they are associated with higher market value, but end up consuming relatively less nutritious foods from their own production, without using the proceeds from sold crops to buy nutritious foods, thereby affecting their children's nutritional status.
- Third, factors that favour dietary diversification may not be part of the policy agenda geared towards improving dietary diversity and nutritional status of the children. This anomaly needs to be seriously addressed.

Recommendations

- Enhancing market infrastructure, which will enable farmers to improve and transform agricultural commercialisation, thereby improving their incomes.
- Promoting formal education, especially for female members of the household can lead to judicious use of the revenue obtained from sales of agricultural products, thereby leading to improved diet quality and nutritional status of children, and overall dietary diversity of farm households.

Conclusions

Production for market sales opens the possibility of using revenue from crop sales to buy some important food items in markets instead of relying solely on own production. In addition, diversifying diets with enough food is a sustainable way of containing malnutrition. The challenge, however, rests with changes in income and variability in prices over time, which tend to affect the consumption of high value foods, especially for households with low incomes. In general, the study underscores the value of market participation. Enhancing market infrastructure can enable farmers to improve and transform agricultural commercialisation, thereby improving their incomes. However, it may not deliver on improving diet and nutrition status if the proceeds from sales of agricultural products do not translate into the buying of diversified and more nutritious foods.

About this Brief

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Better Storage Could Reduce Billions Worth of Food Loss and Improve Food Security

By

Martin Julius Chegere, Razack Lokina and Agnes Mwakaje

Improved storage methods can lead to lower food losses and improve household food security status among smallholder farmers.

Introduction

In recent years, concerns over poverty and food insecurity in Africa have heightened due to rapid population growth, and climate variability. Over the past decade substantial effort

and resources have been allocated to increase agricultural productivity. Despite being crucial for improving incomes and ensuring food security, increasing agricultural productivity may still be insufficient to solve the problem of food insecurity. Expansion of food production contends with challenges such as limited land, water sources and increased weather variability due to climate change face (Aulakh and Regmi 2013). Increasingly, food loss reduction can provide a more environmentally-sustainable and cost-effective solution to food security and income improvement than increasing production in a world with limited natural resources and in an era of high and volatile food prices (FAO and World Bank, 2010). Nevertheless, so little has been done to study what happens to the harvested crops and how to reduce food loss. The main objective of this study, therefore, was to analyse the impact of post-harvest management training and the supply of hermetic (airtight) bags on household food security status.

Background

Sub-Saharan Africa (SSA) is still highly dependent on agriculture and maize is by far the most important crop in SSA. Out of a total annual grain production in SSA of 112 million tonnes, maize contributes 40% (World Bank, 2011). In SSA agriculture is mainly practiced in the rural areas where most of the population lives. Despite being the main food producer for both rural and the urban populations, rural agricultural households in SSA remained the most food insecure, undernourished and poverty-stricken areas of the world. One of the reasons behind such a plight is elevated levels of food loss. Food loss is the decrease in food grain that occurs between harvest and the moment of human consumption. It is estimated that about 20-30 percent of agricultural produce in Africa suffers post-harvest losses valued at 4 billion US dollars annually (CIMMYT 2011).

Food loss lowers the producers' income and increases the risk of food insecurity. Food loss may also result in higher food prices, which affect consumers and, especially, the poor, who spend high proportions of their income on staple foods. Food loss also causes the loss of scarce resources such as agricultural inputs and labour used in production (FAO, 2011).

Key messages

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 with two treatments. In the first treatment group, farmers were trained on post-harvest management, and in the second treatment they were given the same training as the first treatment group but were, additionally, provided with hermetic bags for storing maize. Results show that the interventions reduced maize loss and household food insecurity. The intervention combining training and supply of hermetic bags reduced maize loss by 53 percent whereas the training intervention alone reduced such losses by 26 percent. Furthermore, the intervention combining training and supply of hermetic bags reduced the household food insecurity access scale (HFIAS) score by 30.9 percent whereas the training intervention alone reduced it by 10.8 percent 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 households being food secure or mildly insecure relative to the control group. Notably, the intervention, which combined training and supply of hermetic bags had a significantly larger impact than the one providing training only.

Policy Implications

Several policy implications emerge from the study:

- It is important to invest in interventions to reduce PHL to complement efforts aimed to improve food security status for small-scale farmers.
- Training to farmers on post-harvest management and the use of an improved storage technology, hermetic bags are possible and affordable interventions that can reduce PHL and improve food security.
- Interventions suggested are economically feasible for small-scale farmers in Tanzania, with a possibility for scaling up the interventions in Tanzania.

Recommendations

- Increasing awareness among farmers, extension officers, NGOs collaborating with farmers, technology developers and other stakeholders on the extent of food losses, and what these losses imply in terms of lost revenue and food security.
- Supporting training and extension services on modern production methods, harvesting techniques, and good post-harvest handling practices that can potentially lower the food losses.
- Supporting investment in development of affordable modern storage technologies and promoting their usage is essential. Developed technologies should help to overcome the food damage caused by rodents, in addition to availing airtight storage facilities to control moisture keep insects at bay without using pesticides.

Conclusion

Elevated levels of food loss offset efforts aimed to increase food production. This situation increases the risk of food insecurity and low income among smallholder farmers. Maize farmers in Morogoro, Tanzania, lose one-in-every-eight bag they harvest. About two-thirds of this loss occurs during storage. Reduction of post-harvest food losses can increase the food available for consumption at the

household level and, thus, improve food security status. It can also increase the income of producers, especially in the regions where crop production contributes a high proportion of incomes such as rural households in Africa. It will also ensure that the limited resources used in production do not end up being wasted through post-harvest food losses.

About This Brief

This brief is based on the results from:

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Eco-Friendly Food Packaging Materials from Agricultural Waste Biomass

By

Jerome M. Bidu[a], Liberato V. Haule[a] and Lilian D. Kaale[b]*

Summary of key messages

This policy brief focuses on raising awareness on supporting local industries and processors in manufacturing food packaging materials using agricultural waste biomass against the backdrop of poor strategies in promoting our local industries due to poor infrastructures and lack of an enabling environment. From this background, there is a need to establish good infrastructure in technology, financing, policy framework, and administration to boost the growth and transformation of local industries. Post-harvest losses and environmental pollution caused by lack of appropriate packaging materials. In this regard, it is essential to use food packaging materials that are not only biodegradable but can also protect food without compromising its nutritional value and physical properties. Such value-adding food packaging materials are critical issues in Tanzania specifically and Africa generally. To achieve this objective, there should be a political willingness to support the development of food packaging materials from agricultural waste biomass.

Policy Recommendations

- Lack of an appropriate packaging materials can result in food spoilage and, hence, incur huge post-harvest losses.
- The post-harvest losses are largely associated to food and nutrition insecurity and malnutrition.
- Availability of appropriate food packaging can reduce post-harvest losses and enhance food security.
- N-biodegradable plastics-based food packaging has become a heavy burden and a growing environmental pollutant in recent decades.
- A long-term solution requires the development of affordable alternative biodegradable food packaging materials based on plant fibres and agricultural waste biomass.

Background

Food security remains a high priority development agenda issue in developing countries. Tanzania's agriculture sector faces multiple challenges, with one of the most pressing being insufficient diversification into higher value-adding marketable products with a sufficiently long shelf-life. Other challenges facing agricultural produce in Tanzania include wastage, and post-harvest losses. Post-harvest

losses at almost every stage of the food chain can be reduced using appropriate packaging (Wohner, Pauer, Heinrich, and Tacker, 2019).

Packaging is pivotal in containing and protecting food's progression from the producer to the end-user in the supply chain (Opara and Mditshwa, 2013). Conventional food packaging materials are plastic-based, non-biodegradable materials that wreak havoc on the environment. Moreover, plastic-based food packaging has become abundant in recent decades despite increasingly posing a real environmental threat. The Tanzania government through National Environmental Management Council (NEMC) has prohibited the use of some of plastic-based packaging materials under the Environmental Act of 2019 (United Republic of Tanzania [URT], 2019).

With a projection of a 50% increase in global food supplies by 2050 due to the soaring global population growth, the demand for food packaging would continue skyrocketing. Thus, there is a need to produce locally-available, environmentally-friendly (biodegradable) food packaging materials. Various biodegradable food packaging materials are producible by processing agricultural biomass e.g., cassava peels, avocado seeds, maize husks, wheat straw, rice straw and banana peels (Mostafa *et al*., 2018).

Research have been conducted on extracting fibres from different plants such as banana (stems), maize husks, taro (stems), and by-products of some plants such as sugarcane (bagasse). However, few studies have been carried out on the extraction of fibres from agricultural wastes for use in food packaging. Thus, practical use of agricultural waste for food packaging application could become a major discovery in this direction.

About the study/project

Research on the development of the alternative materials for food packaging to reduce environmental impact caused by non-biogradable packaging while reducing food spoilage reduction of post-harvest losses is scarce. This study, therefore, was based on developing a biodegradable food packaging material based on cellulosic fibres from agricultural biomass. The technique of extracting natural fibres from plant stems and other agricultural biomass involves the removal of pectin, which binds the fibres to the woody inner core of a plant's materials (Lee, Khalina, Lee, and Liu, 2020). The fibres from maize husks were extracted with the use of caustic soda at a temperature of 100^{o}C. The food packaging materials as fabrics were formed by varying the proportions of sisal fibres and maize husks fibres cast with corn husk pulp.

Findings

Agricultural biomass waste has been used in developing food packaging, with promising results. We successfully developed a biodegradable food packaging material based on cellulosic fibres (maize husk and sisal) and cellulose pulp (maize husk). The results show that fabrics developed have reasonably decent properties for food packaging, which includes mechanical properties, water vapour permeability, appearance and smoothness of the surface. The resulting food materials could be modified into different 3-D structures for food packaging.

Policy implications

Revising the policy to promote the use of agricultural biomass and plant fibres for manufacturing food packaging materials have multiple benefits. To begin with, the use of agricultural biomass adds value to those materials and, hence, boosts the livelihoods of the farmers. Second, the use of agricultural biomass lowers the costs of food packaging materials because they are cheaply available, and the resultant manufacturing technology is affordable. Third, the use of plants fibres diversifies the use of fibres produced locally in Tanzania such as sisal, hence increasing the demand of those raw materials. The idea also helps valorise the agricultural waste and, hence, enhances the economy and livelihoods of farmers. The project also attracts more investment into the agricultural sector Furthermore, the burden of environmental pollution caused by packaging based on petroleum products would be solved in addition to covering the deficit of food packaging materials caused by banned plastic packaging. Therefore, the proposed agricultural waste biomass if properly implemented and scaled up could reduce the post-harvest losses and help ease environmental problems. In addition, over-dependence on imported of food packaging materials would be significantly reduced, hence improving the growth and transformation of local industries.

Conclusion

Overall, there is a need for the government to revise its policy on the transformation of local industries to promote local manufacturing industries, encourage sustainability, boost economic empowerment and create jobs. Transforming the food production processes including food packaging materials need a firm political will and commitment. The reduction of the use of plastic materials for food packaging received a political willingness in Tanzania and hence materials were prohibited. Yet, the development of new alternative materials to plastics for food packaging has not received enough attention. It is, therefore, our aim through this research to call upon policy-makers to show interest in investing more into the use of agricultural biomass for the production food packaging materials. The research provides policy-makers with scientific information to facilitate the

making of informed decisions when developing plans and policies on food packaging. Finally,, the research would also strengthen national research capacity in food packaging and implementation of agricultural plans for the country's development.

Acknowledgements

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Policy Brief on the Effects of Monoculture Plantation on Ecosystem Services in the Southern Highlands of Tanzania

By

Luth Mligo, Catherine A. Masao & Pius Z. Yanda

Key Summary

This policy brief forms a part of a report on the effects of exotic plantations on ecosystem services—indigenous plants, soil, and water in the southern Highlands of Tanzania. Due to a rise in price and demand for timber in recent years, many rural people became compelled to plant trees for poverty alleviation, minimise over-extraction of natural forests for charcoal, firewood, timber and carbon sink. This study was carried out in Njombe region since it is a the leading area with exotic tree plantations in Tanzania. The study found that, from 1990-2020 there was an increase in plantation forests and an increase in natural forests but a decrease in grassland and bushland and water quantity. In fact, a large part of indigenous plants had been replaced by plantation forests. Efforts have been made by the government and other stakeholders on natural forest conservation under well stated policies and legal framework leading to their increase. There is a need to consider the danger of monoculture plantation on ecosystem services by reviewing the existing policies and emphasising on indigenous trees planting that balances the biotic and abiotic environment for future generations.

Introduction.

Globally, the role of natural plant diversity on ecological system is well-documented as it acts as a habitat, and plays a crucial role in nutrient cycling, water cycling, climate regulation, and carbon sequestration. The depletion of natural forestry for fuel wood, charcoal and agricultural practices have led to the introduction of fast-growing monoculture plantations as one of the alternative measures for natural forest conservation. The effects of exotic monoculture plantation on ecosystems services including indigenous plants, water and soil have been reported in different parts of the world as they lead to the disappearance of indigenous plants and decrease in water quality and quantity in addition to altering soil fertility (Amato *et al.,* 2017, Andreas *et al*, 2017, Aliloo *et al.,* 2012). In Tanzania, the government in collaboration with other stakeholders such Participatory Forest Plantation Programme (PFP) as well as private companies including Green Resource (GR) emphasised on tree planting in the southern highlands of Tanzania was done by to increase income and carbon sink while reducing over-exploitation of natural forests for timber, firewood and charcoal. However, the emphasis on monoculture plantation did not consider their effects on ecosystem services. This study, therefore, was carried out to determine the effects of exotic trees specifically pine (*pinus*

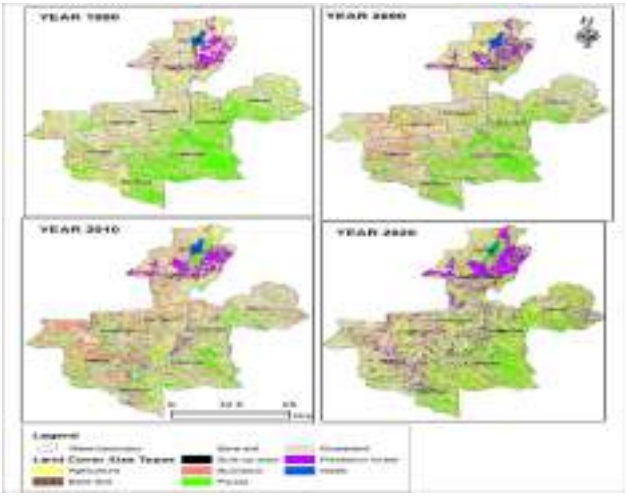
patula), eucalyptus sp and black wattle (*acacia mearnsii*) on selected ecosystem services such as indigenous plants, soil and water. The study also explored how the community benefited from exotic plantation compared to other crops. Landsat images were used to classify the types of land use and land cover change in an area.

The study was conducted in Yakobi, Uwemba, Utalingolo, Lugenge, Luponde, Ramathani, Matola, Madope and Igima wards in Njombe region. Njombe region was selected since it is one of the leading trees growers in the Southern Highlands of Tanzania. (Mankinen et al., -2017). Exotic plantations such as pines (*pinus patula*) are killing the understory plants. The decrease in water quantity from 1118ha in 1990 to 563ha in 2020 has led to scramble for water during the dry season when most of farmers practice irrigation farming. Unlike black wattle and eucalyptus, the soil under pines is dry and compact with low infiltration rate. However, exotic plantations have been an alternative to exploitation of natural forests for timber, firewood and charcoal, which has led to the decrease in deforestation and increase in natural forest. Exotic plantations also help to generate income for households even though they attract low prices and take a long period to mature forcing many farmers to shift from tree planting to avocado and other crops. Emphasis on other crops that produce annual products such as avocado, macadamia and a variety of fruits should be done. The recommendations of this policy brief focus on environmental conservation, climate-smart agriculture, capacity-building on technology and allocation of wood processing industries. Despite the change in land use and land cover, Southern Highlands of Tanzania remain one of the most important zones for climate regulation.

Key Findings

Land cover change

There is a significance change in land cover from 1990 to 2020 (Figure 1 & Table 1). During this period, plantation forests increased from 5,410 to 27,737 Ha; agricultural land shot up from 32,313 to 35,514; water decreased from 1,118 to 563 Ha; natural forest rose from 49,647 to 51,100 Ha; and grassland dropped from 73,166 to 44,88 Implicitly, the exploitation of natural forest for timber, charcoal and firewood had decreased, with exotic trees taking their toll. Indeed, there is an increase in plantation forest, which has replaced large part of grassland and bushland, hence threatening the biodiversity of the area. Conservation of natural forests and water resources had entailed restricting bottom valley cultivation. Whereas natural forests and plantation forests had increased, water quantity had been decreasing. Thus, more research is required by the forest and agricultural authorities and immediate measures to prevent adverse effects in future.



LAND COVER CHANGE										Change rate (%)		
Land Cover	Year: 1990		Year: 2000		Year: 2010		Year:2020			1990-2000	2000-2010	2010-2020
Land Use/ Cover Types	Ha	%	Ha	%	Ha	%	Ha	%		Ha	Ha	Ha
Total	32,313	18	26,472	14	26,338	14	35,514	19		-2	0	3
Agriculture	1,208	1	2,183	1	1	0	8	0		6	-77	21
Bare Soil	60	0	697	0	1,443	1	1,710	1		25	7	2
Built-up Area	20,628	11	30,985	17	37,045	20	22,040	12		4	2	-5
Bushland	49,647	27	43,794	24	34,098	19	51,100	28		-1	-3	4
Forest	73,166	40	68,207	37	69,608	38	44,880	24		-1	0	-4
Grassland	5,410	3	10,095	5	13,630	7	27,737	15		6	3	7
Plantation forest	1,118	1	1,116	1	1,386	1	563	0		0	2	-9
Water	183,550	100	183,549	100	183,549	100	183,552	100				
TOTAL												

Table 2. Land cover change between 1990 and 2020 in part of Njombe region

Effects on water quantity

Water quantity decreased from 1,118 ha in 1990 to 563 ha in 2020 (Table 1), which affected irrigation farming during the dry season. The increase in plantation and emphasis on the conservation of natural forests could lead to an increase in water quantity but the situation is reversed. This reversal is probably caused by exotic plantations, especially *eucalyptus*, which tend to lose large amounts of water through evapotranspiration (Jobbagy *et al,* 2012) and pines which form a bed of slimy litter that increase run-off and prevent the rainwater from entering the soil, hence making the soil harden with low infiltration rate (Dye 2013). More

research is needed under the ministries of water and forestry in this area coupled with measures for preventing more reduction in water quantity in subsequent years.

Effects on indigenous plants diversity

Farmers in the study area mostly preferred Pine trees for timber, but these species have been killing the understory indigenous plants, hence affecting the ecology of the area. They form a bed of undecomposed litter that inhibit seed germination and prevent the growth of other plants (Fig. 2). Coniferous trees such as pines and eucalyptus are ever-green throughout the year with wide canopy cover that hinders the passage of light to the understory plants, hence leading to their disappearance. The increase in exotic plantation have also led to the decrease of some ecosystem services such as wild medicines, wild foods and habitats. Many villages were found to be aware of environmental conservation as evidenced by their establishing environmental committees that work on fire-outbreaks and protecting small areas for grazing. Nevertheless, they witnessed the loss of indigenous plants, especially medicinal plants. Some of them worry that in future the area could turn into a green desert because once the trees were harvested there was hardly time for the land to recover its original vegetation. Emphasis on sustainable indigenous trees planting is required by both the government and private companies in a bid to conserve natural forests. Natural forests are more friendly for commercial bee-keeping than exotic ones. Such a situation can provide income to the people while balancing the abiotic and biotic environment. In addition, an environmental policy on the danger of monoculture plantation should be reviewed by the Ministry responsible for the environment to ensure sustainable forestry.

Figure 2. Disappearance of indigenous plants and slow decomposition of pine litter at Madope Village.

Effects on soil fertility.

Unlike eucalyptus and black wattle, the soil under pines tend to be dry and compact. In mature pine plantations, the undecomposed pine litter rich up to 30cm, which means there is slow microbial activity, which results in poor soil formation and low soil organic matter (Fig. 2). After harvesting trees, some farmers reuse the same farms for crop cultivation but it takes 2-3 years for the farm to gain its fertility due to slow decomposition of pine litter. Soil pH has been found to be very low, indicating low microbial activity resulting in poor soil fertility and toxicity. Capacity-building by environmental and agricultural stakeholders is necessary to impart knowledge among exotic tree farmers on soil conservation including burning tree residues after harvesting to increase the pH of the soil and enhance early recovery of the soil for crop production.

Effects of livelihood

The study found that, exotic plantation increases the household income despite taking a long time to mature. Moreover, currently they are sold in low discouraging prices. Pines take 15 years and eucalyptus 7 years to mature for harvesting. During this period, farmers engage in the production of other crops that provide their annual income and sustenance. A slump in the price of timber has discouraged many farmers from continue planting trees and some farmers harvest their young trees and replace them with avocado, whose annual returns commanded reasonable prices. Some farmers used their farmland, which had lost fertility for planting trees as one of the methods of making them regain its fertility. This affects the nearby farms by making barrier to pollinators including wind pollination, hence leading to poor production of in nearby farms. This led to the shortage of cropland and conflicts in some villages. Some village authorities have distributed their land for trees plants to save arable land for crop production. The Ministry of Trade and Industry in collaboration with district councils should create a room for crops and wood processing industry to add value to increase the producer prices and raise people's incomes and the government economy.

Existing land use plan

Land use plans among some villages have covered different uses. However, it was observed that some villages lacked such land-use plans for their land that guided them on sustainable forestry and agriculture. This was evidenced in some of the villages where some individual arable lands had been used for trees planting. The implementation of land use plan through districts councils in collaboration with village councils will help to safeguard the depleting ecosystem services of the areas.

Existing stakeholders' collaboration.

The emphasis on trees planting in the southern highlands of Tanzania is done by the government, private companies and institutions. The government co-operates with countries such as Finland in tree-planting to minimise

overextraction of natural forests for timber, firewood and charcoal, alleviate of poverty as well as carbon sink. The Participatory Plantation Forestry Programme is one of the bilateral co-operation initiatives between Tanzania and Finland that operates in the southern highlands under slogan (*Panda miti kibiashara; plant trees for business).* The Tanzania Forest Service Agency (TFS) focuses on natural forestry conservation, afforestation and reforestation. Green Resources and TANWAT and many other companies also co-operate with the government at the village level in trees planting. However, significant emphasis is done to the alien fast-growing monoculture plantation such as pines and eucalyptus, which account for the effects on indigenous vegetations and water. Emphasis on indigenous trees planting could, therefore, balance of ecosystem services.

Existing Policy and Legal frameworks

Usually, there are well-documented policies that consider the conservation of biodiversity. However, very few among them like the national environmental policy indicate the danger of monoculture plantation, let alone state that natural forest would not be replaced by exotic species. Following the decline of some ecosystem services such as water in recent years in the southern highlands of Tanzania, the review of policies on conservation of biodiversity under the existing exotic plantation forestry would lead to safeguarding the natural resources to prevent their disappearance that could affect livelihoods of the poor and the national economy.

Conclusion and Recommendation

Conclusion

Unlike the other parts of Tanzania, natural forests are increasing in the southern highlands of Tanzania with minimum deforestation for firewood, charcoal and timber. Southern highlands remain one of the important areas for climate regulation. The effect of plantation agriculture on water, soil, indigenous plants and community's livelihood may be managed by the government and stakeholders, who need to emphasise on sustainable land use practices. Additionally, more research should be done on why there has been a decrease in water quantity in the area.

Policy Recommendations

Alternatives to exotic monoculture plantation: The Ministry of Agriculture in collaboration with the Ministry of Water Resources should revise land use to ensure the conservation of natural vegetation and water resource for future generation. Presently, there was no clear policy statement that explains plantation forests and their effects on water and soil. Thus, more emphasis is necessary to grow other plants that produce annual products such as avocado, macadamia and a variety of fruits. Those plants provide similar benefits to those of plantations, for example, carbon sink. In addition, they have well-decomposing litter, and produce many flowers that enhance other economic activity such as bee-keeping and can co-exist with legumes and wheat. This undertaking can also help to conserve water even though more research is still needed on the cause of the decline in water quantity in the study area.

Environmental conservation: There is a need to safeguard indigenous plant species based on their importance in ecosystem, for example, water, nutrients cycling, honey, wild food like mushroom and medicines. These resources can significantly ease the effects on the livelihoods of the people who depend on them. Village land use planning and campaign for environmental conservation should be emphasised to allocate and protect ecological areas to maintain their ecosystem. In this regard, the Ministry of Land and Human Settlement could collaborate with district councils and village councils. In fact, some villages lacked land use plans. Land use plans serve as a guide for sustainable agriculture, forestry, livestock, wildlife and environmental conservation.

Climate-smart agriculture: Promotion of climate-smart agriculture should be considered for sustainable land use for agricultural practices favouring the conservation of ecosystem services. Such plantation agriculture should go hand-and-hand with the conservation of indigenous trees genetic resources and the flora and fauna. This can be done by planting different species of indigenous plants in different landscapes that may enhance the balance between biotic and abiotic environment. In this regard, the Tanzania Forest Service Agency in collaboration with other stakeholders in districts and village councils can execute such an initiative. After all, Natural forests provide more ecosystem services than exotic forests.

Allocation of wood processing industries: There should be allocation of several wood processing industries by the Ministry of Industry and Trade in collaboration with district councils to add value to the tree products. Doing so would lead to an increase in the value of trees products and increase the communities and national income.

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Sub-Theme 3:

Molecular Bioscience

The Potential of Plants-Derived Natural Products in Managing Neurodegenerative Disorders: A Case Study of Compounds from Medicinal Plants in Tanzania

By

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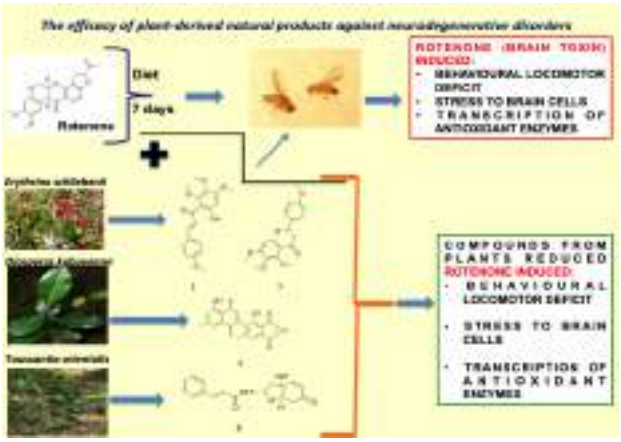
Key messages:

- Neurodegenerative disorders are among chronic non-communicable diseases (NCDs), which are due to improper functions or death of cells of the central nervous system (CNS).
- Currently, the major sources of sickness and mortality in sub-Saharan Africa (SSA) countries including Tanzania are NCDs.
- Neurodegenerative disorders are complex disorders caused by both environmental and genetic factors; meanwhile, the present conventional treatment relies on the symptoms using synthetic drugs.
- Natural plant products potentially have a more positive effect on preventing or managing such diseases than the current synthetic drugs in use that have shown adverse side-effects.
- Policy on traditional medicine exists; it requires government action on linking research institutions and the pharmaceutical manufacturing industry, plus active government support of basic and scientific research on medicinal plants for promotion and improvement of traditional health services.

Graphical summary



Background

Neurodegenerative disorders are among chronic non-communicable diseases (NCD) together with cardiovascular diseases, diabetes, and cancers. In sub-Saharan Africa (SSA) countries including Tanzania, the burden of communicable diseases outweighs that of NCDs but in more recent years the major sources of sickness and mortality have been NCDs. Estimations suggest that the NCD burden would overtake that of infectious diseases by 2035 (Nyirenda 2016). Concurrently, there has been an increase in the elderly population in countries due to improved health facilities. In Tanzania, for example, data shows that the average life expectancy rose from 33 years in 1960 to 65 years in 2020 (UN-Word Population Prospective 2020). With the recent increase of NCD in SSA countries, a higher life expectancy in the region could be endangered in the face of further rise in NCD cases, especially those related to the central nervous system (CNS) such as Alzheimer and Parkinson diseases.

Since ageing is one of the risk factors for neurodegenerative diseases and treatment/management relies on synthetic drugs with adverse side-effects, Natural products (NPs) from plants are foreseen to be the best alternatives in managing and serve as food supplements to prevent NCDs. In this regard, the search for bioactive phytochemicals from plants with the ability to protect brain cells is growing. The Natural Products Research Group (NPRG) in the Chemistry Department of the University of Dar es Salaam has for many years been accumulating natural products library from Tanzania's plant biodiversity (Nkunya, 2005; Nyandoro et al. 2014, 2015, and 2017).

In line with the current approach of searching for neuroprotective and antioxidant phytochemicals, we used combination of biochemical, molecular, and behavioural techniques to screen the safety of five (5) natural compounds derived from plants found in Tanzania. Among 5, four compounds that were not toxic showed the potential of protecting the brain cells and, hence, reduced the PD like-motor symptoms using the animal model, the *Drosophila melanogaster*). The selected compounds namely, 5,6,7,4´-tetramethoxyflavone **(1),** 6-hydroxy-2,3,4,4´-tetramethoxychalcone **(2)**, 6-methoxyhamiltone A **(3),** diosquinone (**4**) and toussantine D (**5**) (Fig.1) possess antimicrobial, anticancer cells, antiviral or antioxidant properties.

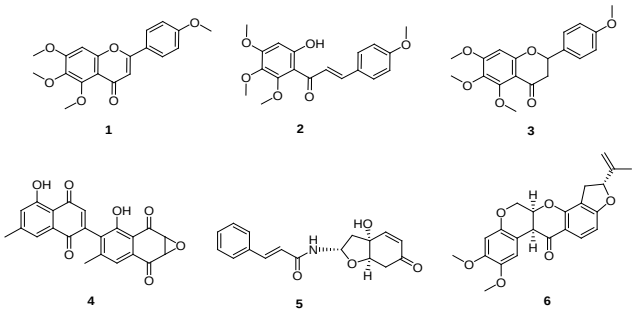


Fig. 1*: Chemical structures of the compounds used in this study*

Findings:

Toxicity screening of selected test compounds

The toxicity effect of five compounds (1-5) was evaluated in living *D. melanogaster* flies. The study showed that all the studied compounds had minimal effect on the death rate of the tested flies except for compound (**1**). Although compounds 1-3 are all flavonoids, they showed different survival responses in the flies tested. Compound 1 with concentrations ranging from low to high values caused high death rates among flies within three days of exposure. Lethal concentration (LC_{50}) of each compound was determined, the results of which are presented in Table 2 (Siima et al. 2020). These findings provide evidence that sensitise on the existing Traditional and Alternative Medicines policy on control of quality and safety of new and in use medicines.

Table 2: *LC50 values in* ***(μM)*** *of the test compounds against D. melanogaster*

Compound	LC_{50}
5,6,7,4-Tetramethoxyflavone **(1)**	91.3[a]
6-Hydroxy-2,3,4,4´-tetramethoxychalcone (**2**)	87.2
6-Methoxyhamiltone A (**3**)	58.0
Diosquinone (**4**)	64.0
Toussantine D (**5**)	>1000

[a]LC_{50} recorded within 3 days of exposure

Plant-derived natural products restoring movement ability in animals tested

In the effort of testing the potency of the compounds studied in reducing PD-like symptoms (movement disability) induced by the chemical rotenone, behavioural analysis was employed. The findings indicate a significant decrease in climbing ability in flies induced with PD (PD flies) compared to the control group (flies without Rotenone). There was also a statistically significant difference either between PD flies and PD flies that were co-treated with the test compounds or L-DOPA (the current used PD drug). Thus, the compounds studied overcome PD-like symptoms (Siima et al., 2020) .

Plant-derived natural products reduce rotenone-induced oxidative stress

We next assessed the level of oxidative stress induced by rotenone by lipid peroxidation analysis. Results show that PD flies had increased concentration of malondialdehyde (MDA), an oxidative stress marker relative to control. This effect was lessened when PD flies were co-treated with compounds 2-5 studied suggesting the antioxidant potential and, hence, neuroprotective ability of the compounds under review (Siima et al. 2020)

Conclusion:

The pure compounds from plants studied have the potential of protecting brain cells from toxic molecules and, hence, help reduce the neurodegenerative disorders. Thus, there is a need to conduct further studies to formulate the anti-neurodegenerative drugs from these compounds.

Recommendations:

- Similar compounds that are available and continue to be discovered by the NPRG, the Chemistry Department, University of Dar es Salaam can also be tested both in pre-clinical and clinical trials so that Tanzanians can benefit from the natural resources available that can later be shared with other communities worldwide.
- The government should create a smooth linkage between research institutions and the pharmaceutical manufacturing industry in addition to supporting basic and scientific research on medicinal plants and other natural resources available for the promotion and improvement of traditional health services.
- Enforcement of policies in place to protect our valuable biodiversity resources is crucial since some medicinal potential plants face conservation threats.
- Policy-makers should exert more effort into controlling the quality and safety of products used in traditional medicines since not all compounds are safe and most products in usage are largely in crude form that contain some toxic compounds that in the long-run can create health problems for users.

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Sub-Theme 4:

Applied Marine Sciences for Sustainable Fisheries and Aquaculture

Seasonal Distribution of Fish Larvae in Mangrove-Seagrass Areas of Tanzania

By

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Introduction

In Tanzania's coastal areas, mangrove forests and seagrass beds form aninterconnected seascape that serves as arefuge, nursery, and feeding ground for a variety of fish (Eggleston et al., 2004). These seascapes concentrate and preserve a multitude of fish larvae coming in fromdifferent directions. Larval fishes,commonly known as "baby fishes," are a type of transboundary biodiversity drifting because of ocean currents from local seas (territorial waters) and international seas, where they are concentrated in calm coastal areas of mangroves, seagrass and other coastal habitats (Azeiteiro et al., 2006). Theavailability of fish larvae in these locations contributes to the adult fish population (stocks) (Houde, 2000). As a result, it is vital to collect detailed information on the abundance (quantity) and distribution offish larvae in shallow water vegetated environments, which will eventually facilitate the compiling of adult fish population information in our Exclusive Economic Zone (EEZ). This study investigated the seasonal distribution patterns of fish larvae in mangrove-seagrass seascapes of Zanzibar (Tanzania).The results revealed variability in abundance and richness across seasons and months, with no distinct seasonal patterns of fish larvae assemblage composition were found in the mangrove and seagrass meadows studied. Thus, monitoring programmes and conservation priorities are advised.

Background

Tanzania has a coastline that stretches for 1,424 kilometres and a 240,000-square- kilometres exclusive economic zone (EEZ) (URT, 2019). The EEZ of Tanzania has a high marine fish diversity, with over 1,000 marine fish species, including 645 coastal species and 46 high commercially valuable species (Fishbase 2021). Seagrass meadowsand mangroves cover the nearshore areas, and serve as resources for protectinglocal and territorial fisheries, thereby contributing to production of fisheries for food and income in coastal communities (Gullström et al., 2002). Through research investigations, Tanzania has a wealth ofinformation on the distribution of adult fish resources in mangroves, seagrass and other coastal habitats (e.g. Dorenbosch et al., 2006; Gullström et al., 2011; Lugendo et al., 2007; Mwandya et al., 2010; Rehren et al., 2018; Sekadende et al., 2020). Furthermore, the Ministry of Livestock and Fisheries, as well as other institutions, continually monitor the state of adult fish stocks through various surveys, such as frame surveys and catch statistics.

Yet, dueto a lack of comprehensive studies and monitoring by the Ministry of Livestock and Fisheries, limited information on the distribution patterns of fish larvae in mangrove and seagrass ecosystems is available (e.g. Hedberg et al., 2019). Due to the sidestep of fish larvae information, coastal vegetation is rapidly losing coverage and health, which may disrupt the life-cycle of fish larvae and result in a decline of fish stock in Tanzania's territorial sea and exclusive economic zone (Sánchez- Velasco et al., 1996). Fish larvae is sensitive to the surrounding environment as only about one percent (1%) of larval fish survive to the adult stage after hatching from eggs (Houde, 1994). As a result, it is crucial to understand the spatial and temporal occurrences of fish larvae in thesecritical habitats for effective conservation and management of fisheries (Ara et., al 2013).

Methods

A monthly survey of fish larvae was conducted for a year in different sites of the Zanzibar archipelago (Tanzania) (Fig 1) to represent a larger portion of coastal Tanzania as well as the Western IndianOcean (WIO) region. In each site, the survey was done in three connected coastal areas (interconnected mangrove, inshore -and nearshore seagrass meadows located withina distance of 0.5-5km).

Fig. 1. The map of Zanzibar (Tanzania)showing locations of study sites

Results

The findings reveal a high abundance of diverse fish larvae varieties in mangroves and seagrass, indicating that these habitats are being used as *feeding and nursery grounds* (Fig. 2). About seven (7) fish larvae families—*Gerreidae, Sparidae, Gobiidae, Apogonidae, Siganidae, Lutjanidae* and *Syngnathidae* (Fig. 2)— were observed almost throughout the year in all three habitats. This demonstrates thereproductive strategy of these fishes in the habitats under review.

There were 42 families of larvae fishes identified, mostly from food and commercially important fisheries e.g. *Majjoras (chaa), Tunas (Jodari), Lethrinidae (changu), Snappers (changu madoa), Scaridae (pono), Labridae (wrasse), Goatfishes (mkundaji), Surgeonfishes (kangaja), Triggerfishes (gona), Jackfishes (Kolekole), Surgeonfishes (puju),* and *Needlefishes* (Fig. 2, Photo1). Most of the fish larvae varieties were frequently found in more than one habitat, thus suggesting an overlapping habitat use across the shallowcoastal seascapes (Fig. 2).

Fish larvae abundance and richness differed across the diverse monsoon seasons in mangroves and seagrass meadows (Table 1). However, theassemblage composition (groupings) wassimilar in all the habitats and monsoon seasons (Fig 4), which resulted from the"multiple use of the habitats" and "smallhome ranges of their parents". Except for a few fish larvae groups, most ofthe larvae appeared to have come fromparents that were *coastal fishes*. The fish larvae abundance showed a peak and were dominated by the smallest-sized baby fish (ofless than 2mm) in April, May and June (Fig 2a and b), which were mostly observed in fish families of *Sparidae,Siganidae* (Tassi), *Apogonidae* (cardinalfish), *Lethrinidae* (changu) *Scaridae* (pono) and *Labridae* (wrasse). This observation informs the "breeding period"of their parent stocks. Evidently, the right management strategies should be applied inthese months.

Table 1. Summary of three-factor ANOVAs for fish larvae abundance richness. Significant values ($p < 0.05$) are shown in bold.

Source of variation	df	Abundance MS	F	p	Family richn MS	F
Season	1	0.024	0.59	0.465	0.051	1.33
Site	1	0.966	21.06	**<0.001**	0.287	10.07
Habitat	2	0.034	0.74	0.482	0.099	2.01
Season x Site	1	0.067	1.45	0.233	0.044	1.58
Season x Habitat	2	0.196	4.28	**0.018**	0.017	0.56
Site x Habitat	2	0.035	0.31	0.721	0.012	0.48
Season x Site x Habitat	2	0.182	1.09	**0.024**	0.016	0.55
Residual	48	0.046			0.030	

Photo 1. photos of baby fishes from families: Labridae (wrasse), pipefishes, Scaridae (pono), Scombridae (Jodari), Lethrinidae (changu)and Sparidae (seabream)

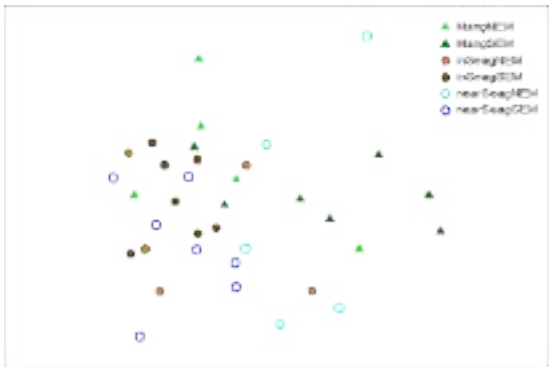

Fig. 4. Non-parametric multidimensional scaling ordination of assemblage structure of the fish larvae in mangrove and different seagrass meadows in SEM and NEM seasons on pooled data from Chwaka Bay and Fumba for the whole sampling period

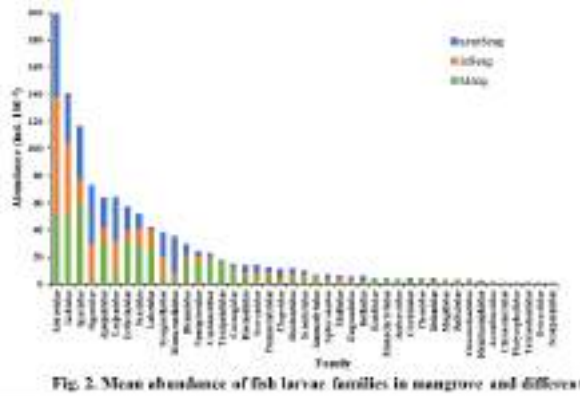

Fig. 2. Mean abundance of fish larvae families in mangrove and different seagrass meadows in Chwaka Bay and Fumba recorded for the whole sampling period

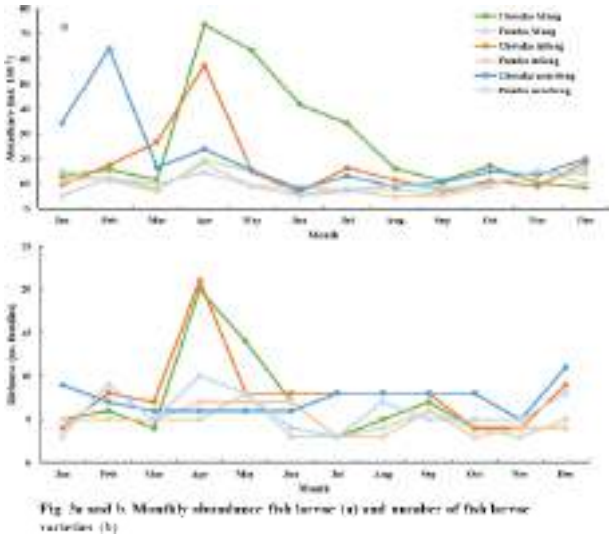

Fig. 3a and b. Monthly abundance fish larvae (a) and number of fish larvae varieties (b)

Policy recommendations

1. Establishment of a continued monitoring programme of fish larvae biodiversity in the coastal areas of Tanzania in the Ministry ofLivestock and Fisheries is recommended. This could help to detect the early changes in fish stocks because of overfishing, environmental change, and anthropogenic activities.
2. Conservation and management initiativesshould *prioritise connected shallow-water seascapes* (rather than single habitat). Doing so could serve as a foundation for the protectionof critical fish larvae habitats, which all work together to keep coastal fish stocks healthy and sustainable.
3. The Ministry of Livestock and Fisheries and other institutions should use the rightmanagement strategies during the peak of fish stocks reproduction.
4. Surveys on larval fish are highly needed. Researchers/scientists can have a positive impact on the overall fish production by investigating larvae fish species in nearshore habitats and taking the right management practices: ***"If researchers could increase larval fish survival from 1% to 2%, the amount of overall fishes available to fishermen, marketplaces, andour plates would double too."***

Conclusion and recommendations

Our findings suggest that mangroves and seagrass meadows are highly linked shallow-water habitats with high fish larvaeretention, hence resulting in assemblagecompositions that are comparable across shallow coastal seascapes. To protect fish larvae and maintain sustainable coastal fisheries, scientists and researchers are being directed towards prioritise connected shallow-water seascapes in management and conservation initiatives.

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Improved Tilapia Strains for Commercial and Sustainable Aquaculture Growth in Tanzania

By

Mbiru Moses, Leonard J Chauka, Dirk Jan de Koning, Christos Palaiokostas, Matern SP Mtolera

Introduction

Tilapia hatcheries in Tanzania rely heavily on importing strains to boost the production of farmed tilapia. Imports are often from Thailand, Uganda and the Netherlands where they have been farmed with substantial output. Desirable candidates have fast growth, high survival rate, resistance to environmental stresses and fitting various farming systems. However, the genetic structure of the imported stocks is poorly understood, especially in Tanzania. Thus, the assessment of genetic diversity and differentiation of tilapia strains introduced in Tanzania is of great concern. The information generated would help to inform fish farmers, hatchery operators, managers, government officials and future breeding programmes in Tanzania.

Background

Capture fisheries in Tanzania has stagnated at around 400,000 tonnes for over a decade thus creating a deficit of about 400,000 tonnes. The sub-sector is unable to feed sustainably a population of 45 million people (NBS, 2018) at an average 17kg/capita/yr. (URT, 2014) in future. Growing at an average annual rate of 8.8% worldwide and 11.7% in Africa, aquaculture, especially of tilapias, has the potential to play a role. Endowed with extensive lakes, rivers, innumerable small reservoirs, valleys and the ocean, potentials for tilapia farming in Tanzania are vast.

Currently, Nile tilapia (*Sato/perege*) is the focal farmed fish in Tanzania accounting for over 95% of the total aquaculture production volume of the country (Kaliba et al. 2006). Farming is mainly conducted in small ponds with cage farming recently being carried out in the main lakes of Tanzania—Victoria, Tanganyika and Nyasa (URT, 2017).

The farming employs more than 18,286 people in Tanzania either on a full-time, part-time, or occasional basis (URT, 2015). Aquaculture growth during the 1990-2013 period had grown for only seven-fold (400– 3,100 tonnes) and recently due to increased importation of foreign strains and/or farmed acreage, its total production (mainly farmed tilapia) has increased to 11,000 in 2016 and it is estimated to reach 18,081.6 tonnes in 2018 (URT, 2019). The output is only 4% of the national annual fish production (Fig. 1). African aquaculture giants such as Egypt and Uganda, aquaculture contribute about 77% (1.1 million metric tons) and 23% (117,600 tonnes) of their annual fish production, respectively (GAFRD, 2014; FAO, 2019). The most feasible factors for low production in fish farming sector in Tanzania are unavailability and poor-quality tilapia seed and feeds. In fact, Tanzania has yet to embrace a global initiative to breed fish selectively, which is often done for chicken, goats and cows.

The fish breeding idea can be traced to 1987 when eight (8) founder tilapia populations mainly from Africa were selected for breeding. After five generations of selections (1988-1997), the outcome was a tilapia strain called "GIFT" (genetically improved farmed tilapia). As strains of GIFT (Figure 2) are fast growing, resistant to disease, and suitable for various farming systems, strains and/or their production technology has been distributed globally (ADB, 2005; Ponzoni et al. 2010; Hussain, et al. 2013; Ansah et al. 2014). In 2015, China alone produced 1.8 million tonnes, whereas other largest producers in Asia (Indonesia, Bangladesh, Vietnam, the Philippines and Thailand) and Africa (Egypt and Uganda) contributed 2.1 million and 932 thousand tonnes, respectively (FAO, 2017).

The argument to import and/or breed GIFT (now reported in 87 countries) officially from the International Centre for Living Aquatic Resources Management (ICLARM, now the World Fish Centre) in Tanzania is still being debated. The major concern is how to boost aquaculture production to commercial scale by using GIFT's technology while conserving biodiversity in our natural water bodies. In that case, both genetic and garden information of the imported tilapia strains are important in informing fish farmers, hatchery operators, managers, government officials and future breeding programmes in Tanzania.

Nevertheless, for increased production, private hatchery operators in Tanzania have been importing GIFT or its descendant strains from Asia, Europe, and within Africa (mainly Uganda). The most common imported strains include the Chitralada, BIG NIN and GIFT from Thailand, the **Silver** strain/YY super males from the Netherlands. Despite using all these breeds to boost tilapia production in the country, the contribution of aquaculture (mainly from tilapia) to the national annual fish production is very minimal, as it has never had exceed 5% in its history (URT, 2014; 2018; 2019). Information on individual strain

performance in the Tanzania environment is scant. Thus, the aim of this study is to investigate the performance of an individual strain both in freshwater and brackish water environment.

Key Findings

- The GIFT strain showed 1%, 47%, 57% and 90% faster growth rate than BIG NIN, Chitralada, "Ruvu Farm" and Silver YY strains, respectively, at Kunduchi. (Fig. 1).
- Likewise, the GIFT strain grew 14%, 17%, 33%, and 83% faster than Chitralada, BIG NIN, "Ruvu Farm" and Silver YY, respectively at Pangani (Fig. 1).
- Overall, all strains performed significantly better when reared in brackish-water than their respective counterparts in freshwater except for the BIG NIN strain.

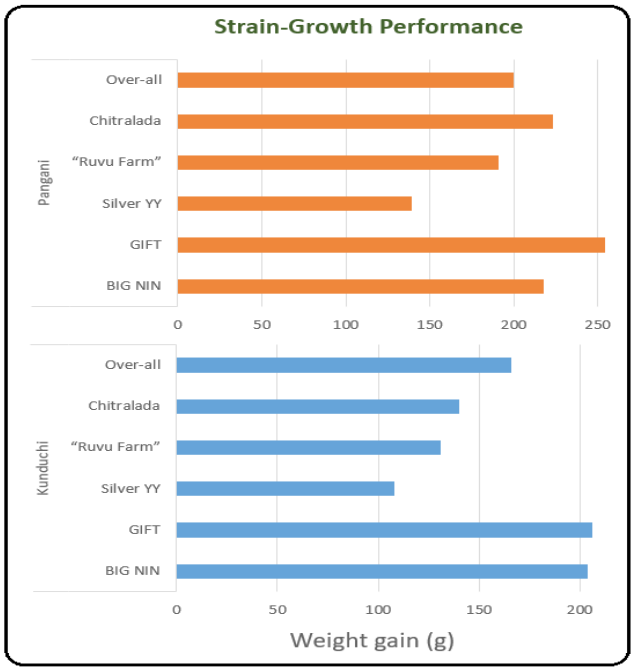

Figure 1. *Strains growth performance*

Photo 1. *A, B, C, D are E are GIFT, BIG NIN, Chitralada, Ruvu Farm and Silver YY strains*

Photo 2. *A, B, C, D are E are GIFT, BIG NIN, Chitralada, Ruvu Farm and Silver YY strains grown to an average weight of 1500g, 1400g, 1200g, 700g, and 600g, respectively after 15 months.*

Potential Nutritive Locally-Available Feed Ingredients Used for Tilapia Farming in Tanzania

By

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Introduction

Aquaculture is the world's fastest growing and most diverse food production sector, contributing around 17% of the total human animal proteins consumption, and 7% of all proteins consumed globally (FAO, 2020), and 30% of the animal protein consumption and 13% of household income in Tanzania (URT, 2015; Mulokozi et al., 2020). The production ventures continued increasing globally up to 82.1 MT and accounted for 46% of the global fish production in 2018 (FAO 2020). In Tanzania, aquaculture production increased to 22,793.2 MT in April 2021 (personal communication). The continuous expansion of the aquaculture industry in Tanzania and across East African region has led to high demand for quality fish feeds (Mmanda et al., 2020a). Currently, there are 11 fish feed plants producing 875 MT, with 472.47 MT imported from different countries worldwide by April 2021 (URT, 2021). The availability of quality fish feeds at affordable price enhanced sustainable fish production and productivity in the country. However, the cost of both local-made and imported commercial fish feeds available in Tanzania and across east Africa region is so prohibitively high that many fish farmers cannot afford it. Currently, the market price of commercial fish feeds ranged from TSHS 2500-5000 (US dollar 1.1-2.16) per kg. The high price probably is due to use of expensive ingredients fishmeal as a primary protein source in fish feeds, whose availability is not sustainable

due to over-fishing and competition with other animals (Mmanda et al., 2020a). Therefore, the investigation of nutritive non-conventional locally available low-cost ingredients is urgently needed.

Rationale

Previous studies show that most of the fish farmers in Tanzania and across East Africa region rely on locally-available materials (Kaliba et al., 2006; Mwaijande and Lugendo 2015). The information on the nutritive value of these local feed ingredients in Tanzania is limited. The use of freshwater shrimps, and brewery spent yeast ingredients have been investigated as alternatives in fish diets elsewhere (Hassan et al., 2018; Mugo-Bundi et al., 2015). However, skeletal remains (fish frames) have not yet been investigated anywhere. Moreover, brewery-spent yeast and fish frames have not yet been utilised as protein sources ingredients in tilapia diet in Tanzania instead of being exported to Kenya for poultry and other animal feed production over several years.

Therefore, studies on the availability and chemical composition of locally-available feed ingredients, potential local feeds ingredients in tilapia diets, effects of interested potential local feed ingredients on growth performance and carcass traits in tilapia juvenile were performed, and presented.

Research Methods and findings

Fresh water shrimps (Uduvi), fish frames (Panks) and brewery spent yeast were local feed ingredients that were identified through a field survey conducted in 9 regions on both Tanzania Mainland and the Zanzibar archipelago, and their chemical composition was analysed according to the AOAC (1990) method. The nutritive potential of these locally available ingredients, as an alternative to fishmeal, were investigated through digestibility studies in Nile tilapia (*Oreochromis niloticus*). Meanwhile, their effects on growth performance and carcass traits were studied in Nile tilapia fed with either fishmeal-based diet or diets in which fishmeal protein had been replaced with 50% of the local ingredients. The feed costs of replacing fishmeal with these alternative ingredients for tilapia were also determined.

According to analysis, 80 % of tilapia fish farmers surveyed (n=202) relied on locally available ingredients to supplement tilapia diets; of which 3% accounted for freshwater shrimp whereas yeast and fish frames had not yet been used as potential ingredients in Tanzania. The chemical composition of these local feed ingredients showed that ash, crude protein, and crude lipid for fresh water were 58.8, 28.0 and 9.6 % DM; 47.0, 35.8 and 15.3% DM of fish frames; and 3.5, 35 and 0.5% DM for yeast, respectively. Freshwater shrimps contained high level of lysine (63 g kg^{-1} DM), 20 g kg^{-1} DM of high level of Methionine +Cysteine and tryptophan (6 g kg^{-1} DM) compared to fishmeal. Moreover, freshwater shrimp contained good mineral content profile compared to fishmeal (Mmanda et al., 2019). Also, in digestibility studies, freshwater shrimp was the most digestible ingredients compared to the other tested diets (blood, marine shrimp, fish frames, brewery-spent yeast, duckweed and moringa leaf; Mmanda et al., 2020 b). Furthermore, for growth performance, feed intake and protein efficiency value of juvenile (male) Nile tilapia were slightly lower with a fishmeal diet compared to other test diets whose fishmeal protein was replaced (50% on dry matter (DM) basis) with cattle blood meal, fish frames meal, freshwater shrimp meal or brewery spent yeast meal (Mmanda et al., 2020 c). Cost analyses for producing tilapia of standard Tanzania's market size (250 g) showed that 50% fishmeal replacement (DM basis) with the selected test ingredients could reduce the costs of feeds by 33% (Mmanda et al., 2020 c).

Policy recommendations

- A balanced nutritional tilapia diet can be obtained using locally available low-cost non-conventional ingredients such as freshwater shrimp, brewery spent yeast and skeletal remains (fish frames; *Lates niloticus*).
- Quality low-cost fish diets can be produced by replacing fishmeal with up to 50% of these identified ingredients without affecting fish growth performance and health.
- The feed costs per kg can be reduced by 33% when fishmeal replaced with 50% of brewery spent yeast; followed by diet fish frames (18%) and freshwater shrimp (9%).

Key messages

- Use of either freshwater shrimp, brewery spent yeast or fish frames as a primary protein source with more than two other local feed ingredients as an inclusion, may produce a well-balanced low-cost nutritional fish diets.
- The use of well-balanced nutritional low-cost diets promote high fish growth rate and health.
- As fish grow faster, this may shorten culture period and lower production costs, hence improving sustainable fish production and farmers' income.

Conclusion

The profitability of small-scale tilapia fish production in Tanzania can be improved by introducing brewery-spent yeast (yeast), fish frames (Mapank) and freshwater shrimp (Uvuvi) as a fishmeal alternative in fish diets.

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Partnering/Participating Institutions

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Fish Farming in Tanzania: What is its Current Contribution to Household Income and Farmers Perception?

By

Deogratias Pius Mulokozi, Francis Pius Mmanda, Paul Onyango, Torbjörn Lundh, Rashid Tamatamah and Håkan Berg

Introduction

The practice of aquaculture mainly in form of small-scale rural aquaculture has generated special interest both in Sub-Saharan Africa (SSA) and internationally (Bene et al., 2016). Over 80% of global aquaculture production comes from small-scale farms owned and managed by families (Gupta, 2018). For many adopters of small-scale aquaculture, this technology is a supplementary mainly in raising extra income, food, and a strategy for diversification (Toufique & Belton, 2014). This kind of aquaculture can be integrated with agricultural activities such as crop and animal husbandry with an aspect of improving the output of the others. In Malawi, Dey et al. (2010) found that integrating fish farming with agriculture increased cash generated sixfold for the rural Malawian households. Shoko et al. (2019) reported comparable results in Tanzania.

Tanzania, which is endowed with the great lakes such as Victoria, Tanganyika, and Nyasa as well as the waters of the Indian ocean, has for a long time relied on capture fisheries. However, with the widening gap between wild fish catch supplies and growing demand from a growing population, a decrease in fish supply is experienced in both rural and urban households, hence threatening fish supply for both local consumption and trade. According to the Ministry of Livestock and Fisheries Development (2020), the per capita consumption of fish in Tanzania stands at 8.5 kg, which is only a third of the global per capita consumption of 20 kg per annum. Thus, fish farming is strongly recommended to bridge the gap and help provide animal protein for a growing population.

Fish farming in Tanzania is dominated by fresh water rural pond fish farming whose size ranges from 150 to 300 m^2 where *O. niloticus* is the dominant species followed by *C. gariepinus* (Kaliba et al., 2006). Other fish species with potential for aquaculture include milkfish (*chanos chanos*) and the mud crab (*Scylla cerata*) that could be cultured in brackish and marine waters. According to the National Bureau of Statistics, Tanzania had about 13,011 fishponds by 2005. Estimates for 2020 stands at 29,979 fishponds (MLFD, 2020).

Despite its introduction over the past 50 years, aquaculture production in Tanzania has been increasing gradually. Whereas lack of enabling policies, techno-knowhow, credits and prohibitive cost of imports and production have emerged as contributory factors (Kaliba et al., 2006). In response to this situation, several solutions such as the development of suitable production systems, availability and accessibility of superior quality seeds and feeds and more appropriate research and extension are proposed (Kaliba et al., 2006). Furthermore, the contribution of rural small-scale fish farming to farmers' livelihood and household economies is little known in Tanzania. Understating factors associated with income from fish farming and the degree to which it contributes to the farmers' household income diversification, would be a good entry point towards more appropriate aquaculture promotion interventions, which in turn could help increase aquaculture adoption rates and production.

This brief uses the data collected April-July 2017 based on field survey and questionnaire interviews with 89 fish farmers and 6 key informants (fisheries officers). The survey was conducted in six districts of Tanzania including Kilombero, Mvomero, Igunga, Songea Urban, Songea Rural and Mbarali. Specifically, the study wanted to answer the following questions: (1) What is the income from fish farming among fish farmers? (2) To what extent does fish farming contribute to the household income? (3) What are farmers' perceptions and plans regarding fish farming? (4) What are opportunities and constraints to further promote fish farming?

Key messages:

Aquaculture contribution to household income

Fish farming contributes to household incomes among small-scale fish farmers on average 13%. However, this contribution is still low compared to many countries in southeast Asia, where it is reported that fish farming contributes up to 86% of household income (Rahman et al., 2011). Lower income contribution from fish farming compared to that from agriculture and other activities could be related to lower input, poor management practices and being non-priority income source. About 31% of the respondents had an average annual income below 694 US$, which according to the World bank, classify these farmers as living in in extreme poverty with an income below the international poverty line of 1.90 US$ per day (Word bank, 2019).

Utilisation pattern of the cultured fish

About 62% of the farmed fish was sold, 36% was used for household consumption and 2% was given away (Figure 1). The overall portion (62%) of the harvest being sold could be associated partly with need for cash for other costs or lack of cold storage facilities, especially in rural areas. The small portion which was usually given away as a gift to neighbours, relatives and friends was perceived to maintaining good societal relationship and well-being within the community.

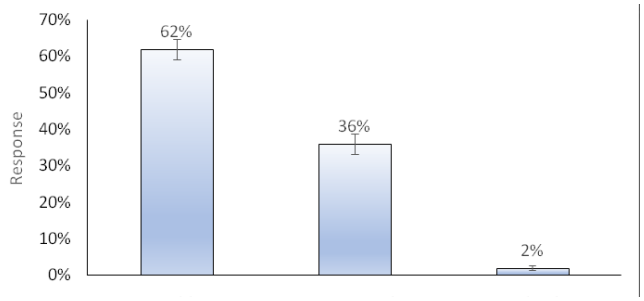

Figure 1. Farmers' estimates on different utilisation proportion of the cultured fish.

Source: Field Data (April-July 2017).

Gender participation in aquaculture

The study results show that 93% of the responding household heads were male, which is a typical Tanzanian household characteristic, the role of gender should be acknowledged as women played a significant contribution to all aspects and stages of household pond fish farming (Figure 2), indicating a need for gender consideration in relation to rural fish farming and development.

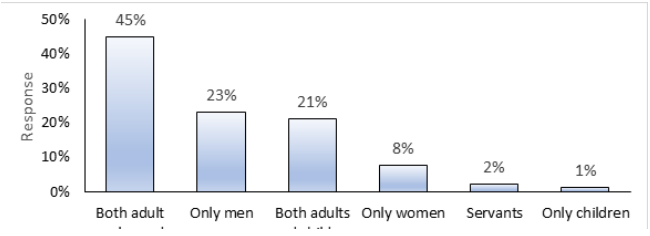

Figure 2. Gender and age groups participating in household fish farming management practices.

Source: Field Data (April-July 2017)

Constraints to aquaculture development

Water use conflicts

Recently introduced regulations that ban any establishment of human activities 60 m from riverbanks and lakeshores had reduced the number of fish-ponds in some areas. Moreover, the introduction of water use permits, which require farmers to pay for water use had also negatively affected a number

of fish farmers in the community. Notably, there is some misunderstanding between fish farmers and policy-makers regarding the regulations introduced. Some farmers felt that fish farming was marginalised when it comes to water uses as compared to other agricultural practices. This calls for a need for water basin authorities to make farmers aware of the newly-established regulations.

Farmers' perception on fish farming challenges and their severity

Using closed questions in a Likert scale (Table 1) farmers ranked stunted growth of fish (64%) to be the most fundamental problem followed in sequence by water related constraints (45%), lack of excellent quality fingerlings (38%), high pond construction costs (38%) and high fish seed prices (31%). Apart from fish seed and water related problems, small-sized harvested fish were associated with the following factors: (1) Lack of excellent quality feeds, which led to fish malnutrition; (2) ponds being distantly located from residential areas, hence making it easy for poachers to capture big fish and leave small ones; and (3) pests like otters, monitor lizards and frogs which negatively affecting the pond yield.

Table 1. Farmers' perception on fish farming challenges and their severity

		Severity				
	N	Not at all	minor	moder-ate	seri-ous	Total
Stunted growth	89	8%	10%	18%	64%	100%
Water shortage	89	19%	19%	17%	45%	100%
Lack of ex-cellent quality fingering	89	39%	12%	10%	38%	100%
High pond construction costs	89	22%	28%	16%	34%	100%
High fingerling price	89	39%	16%	13%	31%	100%
Lack of exten-sion services	89	53%	15%	16%	17%	100%
Lack of land	89	61%	13%	11%	15%	100%
Conflict with other on water use	89	55%	15%	16%	15%	100%
Lack of cold storage facil-ities	89	82%	3%	2%	12%	100%
Lack of buyers	89	89%	4%	3%	3%	100%
Lack of trans-portation	89	90%	4%	3%	2%	100%

Reasons for low aquaculture adoption in the community

Lack of appropriate fish farming skills was the most common factor mentioned for poor community fish farming adoption rate (Figure 3), which was also evident during our field observation. Many farmers did not know exactly their fish-pond size. Since most of the pond inputs such as number of fish to be stocked, fertilisation regime and feed quantity are determined by the pond size, this could have a negative implication for resource use efficiency and pond productivity in general, thus undermining fish farming. This situation calls for immediate improvement of farmers' knowledge through extension services, training and on-farm trials to increase aquaculture adoption rate in Tanzania.

Second to lack of enough fish farming knowledge was water related problems. This was mainly perceived to result from anthropogenic activities, climate changes and policy issues. Farmers thought that due construction of fish-ponds and houses nearby water sources upstream caused water scarcity to fish-ponds located downstream resulting in abandonment of several downstream fish-ponds. Also, climate change related problems such as uncertain rainfall and raised temperatures were thought to cause problems with shortage of water.

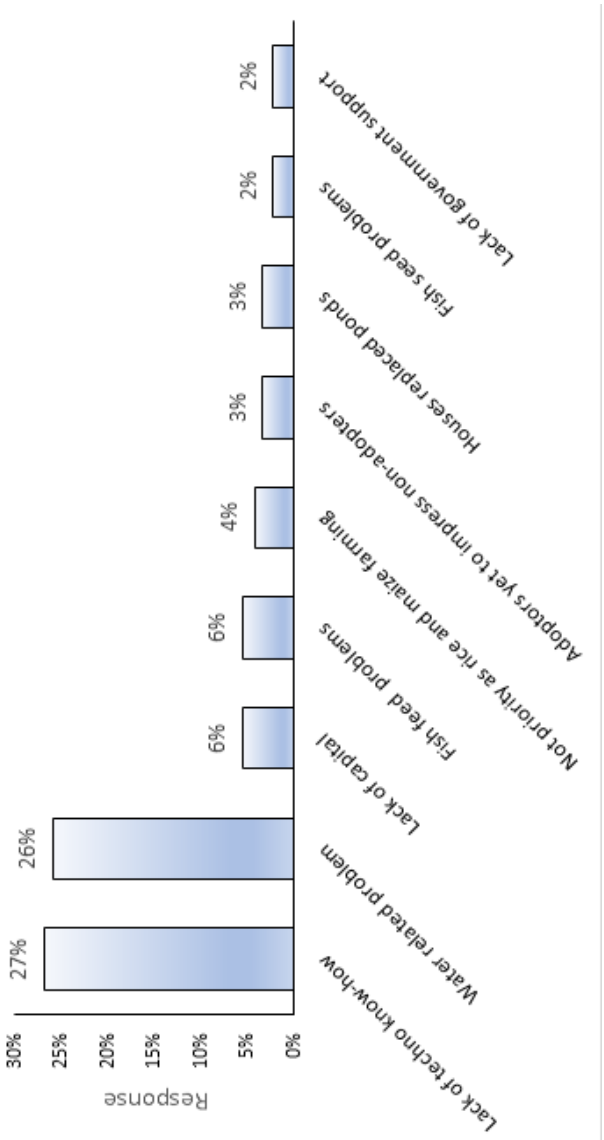

Figure 3. Reasons for poor community fish farming adoption status based on farmers' perception

Source: Field Data (April-July 2017).

Farmers' plans for aquaculture

The majority (64%) expressed a willingness to continue with fish farming at the current scale, 15% wanted to expand their activities, 9% wanted to quit whereas 12% had

not decided whether to continue or not (Figure 4).

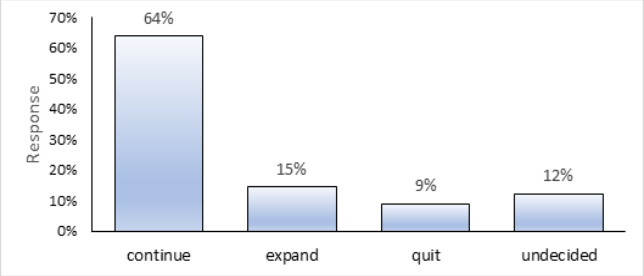

Figure 4. Farmers' plan on fish farming. Source: Field Data (April-July 2017)

Conclusion and recommendations

The study indicates that, although Tanzania's aquaculture like other Sub-Saharan Africa (SSA) is emerging, 13% of the fish farmers household income comes from fish farming. These findings contribute to the ongoing debate on the role of rural fish farming to household poverty reduction and development. However, at the current level of production this contribution is still low when compared to other countries outside SSA. The good climatic condition and the willingness of people to farm fish signals a potential for much higher output from fish farming. Recently, imposed environmental and water use regulation, which were negatively perceived by fish farmers. In other words, there is a need for policy-makers and district fisheries officers to make these regulations clearer for fish farmers to abide by them accordingly.

Acknowledgement

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Sub-Theme 5:

Smart Energy Systems

Enhancing Reliability of National Power Grid through Intelligent Monitoring Mechanism

By

Hadija Mbembati, Hussein Bakiri** & David Makota****

Summary

The target for Tanzania electric energy as per the energy policy of 2015 (section number 3.1.2)[1] is to increase reliability in its transmission and distribution processes. Efforts to establish intelligent grid in Tanzania to enhance power reliability based on ICT raises several issues that require a policy intervention. These issues include the adoption of an intelligent monitoring and control mechanism in the national electricity grid.

Presently, the existing grid infrastructure hinders the policy implementation (reliability achievement) due to lack of capability to engender remote monitoring and control of grid equipment. The existing traditional monitoring and control approaches the national utility company could lead to unplanned outages, power losses, and system overload. This introduces costs to the utility while reducing service reliability. Thus, it is crucial for the government to adopt intelligent monitoring mechanisms to enhance the reliability of the national utility grid.

Background

The average electricity demand in Tanzania has been gradually increasing as the 2015 to 2019 data illustrate[2]. The reason for the heightening demand is due to the growth in economy and rapid perturbation in industrialisation and urbanisation.

Power losses, system overloading and unplanned outages are the main causes of service unreliability in Tanzania. The issue of power losses in Tanzania reached the extent of 28% in 2011[3]. The unplanned outage of electric machinery in the generation network reduces hydropower generation, which in turn affects government revenue (EWURA 2018). Overloading is another major cause of unplanned outage as a study conducted by Ministry of Energy and Minerals with the Japan International Co-operation Agency 2017 (JICA) revealed. Other causes are emergency load-shading and load transfer, Earth fault, cables as Table 1 illustrates. The power loss in transmission and distribution in Tanzania from 2010 to 2014 is as shown in Figure 1.

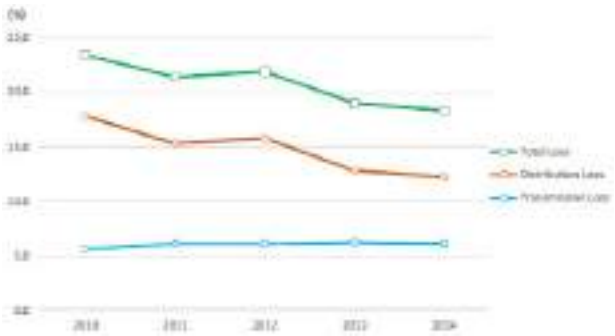

Figure 1. The power loss trend in Tanzania

The total loss, according to JICA (2017), is 18.3% (Transmission 6.1% and distribution 12.2). These statistics show that the distribution loss is high due to rapid expansion of the distribution network.

Table 1: Unplanned outage –Kinondoni south region 2016

No	No of outage	Causes
1	396	Overload, earth fault and power failure
2	291	Reconnection
3	79	Touched conductor
4	103	Brocken, Nocked flashing
5	63	Emergency load-shading and load transfer
6	16	Under frequency
7	2	Cable

Based on the unit cost[4], hourly consumption[5] and outages data[6], the revenue loss is calculated using equation (1):

Where:
Rev. loss =Revenue Loss
=Hourly Consumption per customer
=Number of affected customers per hour
=Hourly outage per year
=Unit cost

Using the formula in equation (1), the revenue loss is as shown in Table 2.

Table 2*: Severity of power outage in distribution network from 2016-2019:*

Year	Affected Customers	Outages/ year	Revenue Loss
2016/2017	775,871	240	10,470,416,848
2017/2018	794,465	379	16,930,788,722
2018/2019	846,070	270	12,844,975,235
Average	**805,469**	**296**	**13,415,393,602**

The impact of having unreliable power service is mainly evident at four angles: Customer dissatisfaction, under-

revenue, high operating costs and staggering economic growth since electricity is the backbone of the country's prosperity.

Thus, the Ministry of Energy (MoE) should formulate policies and introduce regulations aimed to reinforce the adoption of ICT to automate control and monitoring of electric load, transmission and distribution equipment. Survey on the current state of integration of intelligent power monitoring and control mechanism in the national grid affirms the following:

(i) There are no mechanisms integrated in the national grid for anticipating load profile of a particular distribution network, devices and power lines fault prediction and automated maintenance scheduling so that the reliability instruments such as load shading, load balancing, device failure prevention and electricity pricing management remain challenging.

(ii) There is no existing policy or regulatory framework that has thus far touched on the issue of embracing ICT to transform the network infrastructure in place, especially at the secondary distribution segment, into becoming intelligent.

(iii) There are fewer research studies undertaken on the adoption of intelligent mechanisms in the Tanzania national grid to reduce the slope towards strategy initiation process.

Recommendation

The Ministry of Energy should establish a policy that will facilitate the transformation of the traditional monitoring and control mechanisms into automated-based approaches for the grid to become intelligent. The objectives of the policy will be to:

(i) Develop the reliability instruments such as load-shading, load balancing, device failure prevention and electricity pricing management to eliminate outages and manage peak demand.

(ii) Develop and adopt appropriate technologies to curb power losses and improve outage management in a bid to boost revenue to the national utility company.

(iii) Develop and use reliable device and line fault prediction mechanisms and preventive maintenance technologies to reduce operational and maintenance costs.

(iv) Invest and motivate more research for developing and implementing ICT integration solutions for the power distribution network.

Conclusion

This policy brief aims to promote the establishment of intelligent monitoring and control mechanism in Tanzania's national grid infrastructures, such as devices and power lines using ICT. The objective has been to guarantee service availability that, in turn, can benefit both the utility firm and customers to accelerate the country's economic development. Doing so could facilitate transparency in monitoring and guaranteeing equipment conditions and, hence, alleviate the problem of service unreliability. The guarantee of service reliability would further help the utilities to increase their revenues and reduce operational time and cost.

4Santos et.al, 2012

5Shibano et. al, 2020

6National audit Report, 2020

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Advocating for the Deployment of ICT Infrastructure for LV Network Automation

By

Godfrey Chugulu, Yona Andegelile,
Gilbert M. Gilbert, Ally Bitebo

Context of the studies

(i) Currently, operations and maintenance of LV network are done manually, hence making the exercise inefficient.

(ii) Now there is no ICT infrastructure suitable for supporting LV operations/automations.

(iii) The AMR meter data are presently transferred through third party communication network, hence making it costly and insecure.

(iv) Communication network in use lacks redundancy, which makes it liable to communication failures.

(v) All the data management activities are so centralised that inefficiency is an inevitable outcome.

(vi) The use of ICT to enhance electrical system service delivery such as automatic fault management poses a major cyber security challenge.

Summary of findings

- The current manual practices in LV operations is unsatisfactory. The utility should, therefore, consider automating the processes.
- Thus, the company should deploy ICT infrastructure that includes secure and resilient communication network and distributed data management platform.
- The ICT infrastructure should be owned entirely by the utility company to guarantee the required QoS.

Introduction

The economic growth of any developing country depends heavily on the reliability of the electric power supply. Most developing countries including Tanzania, still operate on traditional or legacy grid with a one-way power flow from generation to consumption points. Such legacy grid suffers from lack of automated analysis, limited control, and poor co-ordination between generated and consumed energy, which makes it hard for power utility companies to supply reliable power to consumers. These challenges need transforming the current power grid to smart grid to overcome them.

A smart grid uses ICT infrastructures to monitör, control and optimise the operations of all parts of the power system. This transformation to Smart grid aims to improve the economic performance, efficiency, flexibility, reliability, resiliency, safety, and security of a power system covering generation, transmission, distribution, and consumption operation.

The smart grid uses secured two-way communications, digital technologies, advanced sensing and computing infrastructure and software to provide improved monitoring, protection and optimisation of all grids' components. Maintaining a reliable, uninterrupted, and satisfactory quality electricity service strongly depends on the availability and reliability of a well-dimensioned communication network.

TANESCO has no automation implemented in its secondary distribution networks (low voltage part). There are no sensors, and no remotely controlled actuators. In consequence,, TANESCO has no visibility on that part of the power network. Even if sensors and actuators were there, there is no communication network to transfer the sensed data or the actuating signals.

Currently, all operation and maintenance processes in the low voltage networks in Tanzania are done manually. This manual setup creates many inconveniences and unforeseen losses that power consumers incur. Moreover, TANESCO loses significant revenue as a result of unplanned and prolonged outages. These challenges can be reduced by evolving the current power grid to a smart grid.

Summary of Research

This policy brief is a result of four PhD research undertakings conducted using challenge-driven approaches (CDE) under the iGrid project, which advocates for the use ICT-based solutions to modernise legacy power grid in Tanzania. The research methodology applied was adopted, whereby the researchers used tools and technologies available to address challenges facing Tanzania's utility company. The researchers focused on proposing an ICT infrastructure, which incorporates computing solutions and communication framework with its resilience features and security schemes. Key energy sector stakeholders including Ministry of Energy and TANESCO participated in research area identification, problem formulation, and results/solution validation. Based on the study findings, the researchers produced policy recommendations to the utility company and the government as presented in the following section.

Policy Recommendations

- The utility should consider automating LV operation and maintenance processes thusly:
    1. The government should establish guidelines for automation of LV networks, by preparing questionnaires to collect opinions from power stakeholders.
    2. The government should recognise the Internet of Things and Automation Industry as keys technologies toward 4th industrial revolution, by including IoT in the power grid roadmap, facilitating more research in the domain, and motivating local innovators in IoT.

3. The government should ensure that there is a conducive environment for the coexistence of heterogeneous technologies, by enforcing it through utility company strategies.

- The utility company should deploy ICT infrastructure to support the automation:
  1. The government should facilitate the creation of standards for deploying ICT infrastructure in LV networks by collecting opinions from power and ICT stakeholders.
  2. All deployments, configurations and installations should consider future modernisation demands by implementing utility company strategies.
  3. The government should enforce regulations that require all procurements of ICT hardware and software to comply with open standards for interoperability.
- The ICT infrastructure should be owned entirely by the utility company:
  1. There should be a law to ensure that LV ICT infrastructure is owned by the utility company
  2. The government should ensure the utility company deploy and own offline communication networks for the automation systems such as SCADA system
- The proposed ICT infrastructure should be resilient enough to guarantee reliability:
  1. The government should establish guidelines and framework for mechanisms that facilitate ICT infrastructure resiliency in LV networks.
- The utility company should consider distributing data management processes:
  1. In this regard, the government should establish data catchment zones based on regions for data obtained for the LV network.
  2. There should be technological mechanisms that support zonal data processing to avoid all data being processed centrally.
- The utility company should deploy integrated security schemes in its ICT infrastructure:
  1. As such, the government should facilitate the identification and inclusion of non-mobile phone devices in the Central Equipment Identity Register to prevent IoT devices from communicating with other devices with cyber security attacking interfaces.
  2. Initiatives should be taken to put in place the Incident Response Capability (IRC) to ensure timely countermeasures are taken because of security-related incidents
  3. Security guidelines should be established when private institutions are using government infrastructure to avoid them being the gateway to sensitive ICT facilities

Conclusion

This policy brief proposes the adoption of ICT-based approaches to ensuring seamless integration with the Power Systems (National Power Grid). The policy recommendations it advances align with the National Vision 2025 for reliable power supply. The objective of this policy brief is to attract the attention of the policy-makers on the potential of Industrial 4.0 technologies and reliability issues that stem from the ICT facilities in relation to Power Systems. Inevitably, as a nation, our critical infrastructures are/will be exposed to these technologies and it is better to have these policies in place to ensure the security and safety of our power systems.

Acknowledgements and funding:

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Enhancing Service Restoration in Tanzania's Power Grid using IoT Sensors and Renewable Energy Sources

By

Daudi Mnyanghwalo, Rukia Mwifunyi, Shamte Kawambwa

Summary

Over the years, the Tanzania government has been taking initiatives aimed to improve the efficiency and accessibility of electric power for its citizens. As a part of these initiatives, the government has established the Rural Energy Agency (REA) under the Rural Energy Act No. 8 of 2005. It started operating in 2007 to promote and facilitate the availability and access to modern energy services in rural Mainland Tanzania, where 85% of the citizens reside. As a result, there have been a significant increase in Tanzanians with access to electricity. In 2018, the number of Tanzanians with such access stood at 35.56 % as Figure 1, based on the World Bank development indicators, illustrates:

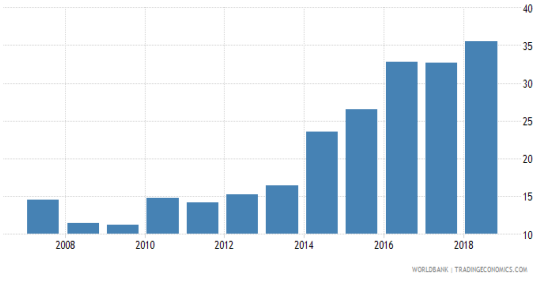

Figure 1: Tanzanians with Access to Electricity

As the network expands, it becomes more vulnerable to the faults, hence introducing new challenges. As a result, there has been an urgent need to find ways for addressing these challenges to ensure that the power services provides are of high quality, efficient and dependable. The advancement of information, communication and sensor technologies facilitates the addressing of these challenges by, for example, ensuring that the restoration is done within the shortest time possible with less human intervention. This policy brief, therefore, highlights the key recommendations for proper deployment of the solution to enhance efficiency and interoperability.

Background

The Tanzania Electric Supply Company (TANESCO) has been working hard to ensure that faults and electrical network malfunctions are immediately addressed to reduce downtime. The implementation of the Supervisory Control and Data Acquisition (SCADA) and Distribution Management Systems using Remote Telemetry Units made it possible for the utility company to monitor the transmission and primary distribution network. SCADA systems have expanded throughout the country to ensure that the transmission network is well-monitored and controlled. However, the DMS has been installed in Dar es Salaam region only as a pilot to monitor the primary distribution network. The service restorations in this part of the network are done manually using relays and manual transfer switches, hence making the entire process cumbersome and very inefficient. Paradoxically, the secondary distribution network is currently not monitored. As a result, the faults are detected manually when customers call or using line surveys the utility personnel conduct. The service restoration is also not implemented in this part of the network, which makes it increasingly difficult to restore services whenever a fault occurs in the network. Inevitably, this causes excessive downtime. The challenges the utility faces in enhancing the automatic restorations include the following:

a. Lack of sensor devices along the lines.
b. Lack of automatic switches to transfer the load for restoration.
c. Inefficient systems to detect and classify faults.
d. Lack of Distributed Energy Resources co-ordination.
e. Inefficient mechanisms for controlling the connected load.
f. Lack of a well-designed mechanism for service restoration.
g. Lack of integration and inter-operability between systems.
h. Reliance on the centralised systems for monitoring, controlling and restoring services.

Recommendations

Through the Ministry of Energy, the Government of the United Republic of Tanzania should formulate policies that will enhance power service restoration in Tanzania's secondary distribution networks using IoT Sensors and Renewable Energy Sources. The objectives of the policies ought to be:

A. Deployment of the IoT Sensors Along the Network

The IoT sensors will ensure the continuous monitoring of the network parameter to detect and classify faults whenever they occur. The faults will be sent to the controller to activate the restoration mechanisms, which will be engaged based on the type and location of the fault. The entire process is intended to be automatic to reduce restoration time. The IoT-based sensor is proposed because it can support two-way communication for efficient network monitoring, and enhance distributed processing. Moreover, it is cheap compared with legacy systems in addition to consuming less power. As such, it can be equipped with a backup system to operate under outage. This IoT-based Sensor also supports a considerable number of measurement channels and can enhance interoperability with other subsystems. Therefore, there is a need to deploy IoT sensors along the network to enhance visibility for efficient service restoration.

B. Deployment of the Service Restoration Management System

The current restoration systems are done manually, with no management systems for power restoration services. Thus, there is a need to deploy a management system capable of enhancing the efficiency of the restoration services. Such a system would ensure that there is proper co-ordination of the restoration activities while fostering the keeping of records of previous activities for analysis. The system would also facilitate the sharing of data on faults and restoration information between the utility and end-users to ensure that they are always updated. The management system should be equipped with supporting subsystems including power flow analysis tool, fault localisation, detection and classification tool, DER co-ordination and services restorations

C. Bidirectional Power Flow Adoption

Currently, the utility company has adopted the unidirectional power flow in the distribution network with only one power source for a specific area. This approach hinders the deployment of the DER in the power system. The advantages of the DER offers many advantages, including Loss minimisation (by increasing revenue for the utility while reducing the cost for the customers), reduction of load-shedding (by increasing customer satisfaction), Improvement of system stability and environmental-friendly energy source. Therefore, the utility company should adopt Bidirectional power flow to enhance renewable

energy sources being installed in primary and secondary distribution networks

D. Installation of Smart Switches

Deployment of the smart switches and circuit breakers along the secondary distribution network plays a significant role in power service restoration. Smart switches facilitate network isolation, load transfer, renewable energy integration and load shedding in case the power supply is too insufficient to supply all loads in the network. Motorized Circuit Breakers need to be placed at the distribution transformers to isolate the secondary distribution network after the occurrence of a fault. The recommendation here is deploying smart switches and motorized circuit breakers along the network based on the network layout to facilitate the restoration processes.

E. Enforcing interoperability between subsystems

The operation of the restoration systems, being part of multiple systems working on the power systems, should comply with the common standards and rules for interoperability. The common standards for interoperability include the ones for communications, hardware, coding, protocols and software. Among others, it should include IEC 61850 and IEEE 802. Therefore, it is recommended that all restoration systems hardware and software be compliant with set standards for interoperability.

F. Enhancement of Distributed Processing

The systems to be deployed for the service restoration should enhance the use of the distributed processing to minimise the single point of failure and overwhelming the network with traffic.

Conclusion

This policy brief promotes the Service Restoration in Tanzania's secondary distribution networks using IoT Sensors and Renewable Energy Sources. The objective is to allow for the deployment of the restoration systems and software along with the network. Doing so could boost the efficiency of the power system reliability, visibility, and reduce losses while improving user satisfaction. The policy is also intended to ensure that the systems implemented comply with the interoperability standards to enhance system integrations.

Reversing Fixed Line Communication Decline in Tanzania's National Grid: A Policy Option

By

Kwame Ibwe & Nerey Mvungi

Summary

There has been a 50% decline in the number of fixed line subscribers from 2014 to 2019[4] on Tanzania Mainland. Banking on the modernisation of the existing power grid, the broadband last mile services such as fixed line communications could be integrated with high levels of security and reliability as one of the additional services in the smart grid system. By 2019/2020[5], 37.7% of the households in Tanzania were connected to electricity, with the number rapidly increasingly. Yet, the existing electrical grid is solely used for power distribution. Due to the long-life cycle and slow updates of electric power devices, a significant part of the infrastructure remains unutilised. Using ICT, power companies can expand into new businesses; however, such an expansion requires considering multiple factors (issues), hence a need for a policy to be in place. One such factor is accommodating a fixed lines communication system for every household in the electricity grid to provide low-cost last mile connectivity. This suggestion is in line with the main initiative of the national ICT policy of 2016 aimed to improve ICT infrastructure to bridge the digital divide and lower the cost of communication[6] since there is no need to install a separate system for communication. However, there is no policy on powerline communication, which has resulted in the non-regulation of this important aspect.

Background

While embracing the prevalence of mobile phones in Tanzania, landlines still play a pivotal role in community service. Land lines are cheap and secure. Emergency responders such as the police and medics could pin-point the exact location of emergency from a land line phone. In this regard, every second counts in an emergency. Even though cellular phones have GPS and only transmit a general location, oftentimes it takes a long time for emergency responders to get the information. Landlines, on the other hand, and are already affiliated with a specific address, so emergency responders can immediately trace that information.

Telecommunication in Tanzania has come a long way from the 1990s, when the country's tele-density was less than 1.2. Today, the tele-density stands at about 67 subscribers per 100 people due to the mobile additions. The fixed line numbers, in contrast, are falling and mobile has emerged as the preferred access medium for us Tanzanians.

4 TCRA Quarterly Statistics July-September 2020
5 REA Energy access and use survey 2019/2020
6 National ICT Policy 2016

Though the industry enjoys tremendous growth of telecommunications in general, which is mostly contributed by the mobile industry, the fixed telephony subscription has experienced a severe decline from 154,420 in 2005 to 151,274 in 2014[7].

The utility company is now upgrading the distribution network by installing control systems such as SCADA for real-time supervisory management. Doing so requires adapting various technologies to manage efficiently manage the integration of fixed communication lines and broadband services to provide smart grid services.

A review of the current contribution of the national grid to new businesses reveals the following:

(i) TANESCO could use the abundance of network resources to expand their businesses into fixed line communications, broadband services, enterprise leasing lines and data center interconnections utilising the optical fibre in their transmission networks, wireless as jumpers for power transformers and distribution network for last mile connectivity.

(ii) Embracing of IP-based networks and compression techniques to ensure high-bandwidth office networks, intuitive HD video surveillance and efficient video conferences.

(iii) Monetising network infrastructure through profit-making business models

(iv) Defining standards for protocols, interfacing, materials and tools, and frequency band for adoption for Tanzania.

(v) Work with TCRA on regulations for integrated communication technologies to optimise communication services costs.

Recommendation

The ministries of Energy and Communication together with the TCRA should formulate a policy or amend the proceedings of the National ICT Policy of 2016 to facilitate the integration of fixed communication and broadband services into the national grid. The objectives of the policy will be to:

(i) Connect cheaper fixed communication lines and broadband services to every household through electric grid.

(ii) Monetise the electrical network infrastructure by allowing more players through new business models.

(iii) Set regulations that will govern service and content providers.

(iv) Set standards to enable the integration of different communication technologies.

(v) Define PLC standards for use in Tanzania.

Conclusion

This policy brief seeks to promote the integration of fixed telephone lines services into the grid for cheaper, reliable and secure connections of voice and broadband.

The objective aims to allow more people access since each connected household could be benefit from cheaper voice and broadband services.

7 National ICT Policy 2016

Sub-Theme 6:

Sustainable Water Resources Management

Inclusive Agricultural Development and Water Resources Management in the Kilombero Valley (KV) River Basin

By

Steven Lyon, Joel Nobert, Lowe Börjeson, Regina Lindborg, Emma Liwenga, Johan Berg, Noah Pauline, Madaka Tumbo, Subira Munishi, Edmond Alavaisha, Victor Mbande, William Senkondo

Summary of key messages

- Investment should be made to intensify small-scale irrigation farming for the remaining part of the valley to recover from degradation and nature conservation.
- Water quality across irrigation schemes were of a good standard under the current management and could support the expansion of irrigation and agricultural practices, but increased irrigation and fertilisation without adaptive management could impact on both environmental and human health.
- Public investment in small-to-medium scale smallholder irrigation canals are more inclusive.
- Current agricultural dynamics in Kilombero suggest that there has been an increase in social differentiation among smallholders.
- Inclusion of low-income farmers in irrigation development remains a challenge.
- Development efforts failed to reach many low-income farmers in Kilombero.
- Mountainous water resources are the main sources of water in the Kilombero Valley Wetland during the dry season.
- The future hydrological behaviour of the KV basin, like many other basins in Tanzania, is uncertain due to climate change and agricultural development

Introduction

Wetland ecosystems are land use development 'hotspots' that have a number of parallel functions related to human nutrition, wildlife habitat, and socio-economic production that need critical consideration to ensure sustainable management. Sustainable management of these ecosystems, such as the Kilombero river basin, is important for food security and the wellbeing of Tanzanians. Apparently, population growth, unequal distribution of wealth and resources, land use and land cover changes, climate changes, and agriculture development present potential challenges to the sustainability of the basin.

The Kilombero river basin is part of the Rufiji Basin located in Morogoro Region in southern central Tanzania. It covers 39,990 km^2. It is bordered by mountains, which extend from a flat and wide plain on the south-eastern side of the Great Ruaha, sloping down into the Kilombero Valley. To the north and west of the Kilombero wetland are the Udzungwa Mountains, and to the south-east, the Mahenge highlands. The natural vegetation is dominated by Miombo forest, which extends from the mountains to the lowlands, which has been little impacted upon by agricultural encroachment. The valley wetland is a complex system including networks of streams, small swamps, ponds and low-lying land partly used for agriculture. The wetland regulates the flow of the Rufiji River and is an important source of nutrients and sediment for downstream mangrove-seagrass-coral ecosystems. Wetland ecosystems are land use development 'hotspots' with a number of parallel functions related to human nutrition, wildlife habitat, and socio-economic production that require critical consideration to ensure sustainable management.

In 2010, Tanzania, under its policy of Kilimo Kwanza, launched an initiative known as the Southern Agricultural Corridor of Tanzania (SAGCOT). This is an inclusive, multi-stakeholder partnership, which aims to develop rapidly the region's agricultural potential through large- and small-scale irrigation schemes. Various stakeholders including the Government of Tanzania (GoT), farmers, agri-business, and companies from across the private-public sector support SAGCOT. The Kilombero basin has emerged to be one of the potential areas for the SAGCOT implementation. This basin contains a 'RAMSAR' site called Kilombero Valley Floodplain, which encompasses several healthy and important wetland ecosystems. In addition, the basin is the upstream of the Nyerere Hydroelectric Power Plant (NHPP) dam, famously known as the Stiegler's Gorge dam site, targeting to generate 2,100 megawatts of hydroelectric power. This strategic positioning makes the area exceptional in terms of emerging challenges as well as agricultural development and sustainable natural resource management.

Water currently available in the Kilombero Valley (KV) river basin is about 13.8 billion cubic metres per annum with the mean monthly flow during the dry season of less than 25% of the wet season. The highest water demand is from the agricultural sector (84.5% of the total demand), followed by the industrial sector (11.8%). Domestic and livestock water demand stands at about 3% and 1% of the total demand, respectively. Most of the irrigated agriculture is conducted with relatively low productivity due to the use of traditional flood irrigation by most of the smallholder farmers. Although irrigation has helped to raise agricultural

productivity, inclusion of low-income farmers in irrigation development remains a challenge as they lack capital to invest in irrigation agro-schemes.

Our recent studies show that local average-income farmers have also benefited from public investments in small-scale smallholder irrigation schemes, which in turn have had positive effects on agricultural development. Hence, based on our findings, fertilisation and irrigation investments at small-to-medium amounts could boost management practices aimed to enhance fertility and enhance production in small-scale farming systems. Notably, such investments would mitigate risks associated with climatic changes and global warming as irrigation increases the carbon stored in soils while meeting agricultural water demands. The findings from these studies suggest that integrated landscape management approaches are necessary to enhance inclusive agricultural development in the Kilombero Basin by promoting water use efficiency to enhance agricultural production. This policy brief, therefore, advocates for planned inclusive irrigated agricultural expansion and introduction of new small- to medium-scale irrigation schemes led and operated by smallholders coupled with extension support.

In Kilombero, prolonging growing seasons and increasing productivity in wetlands through irrigation have been the target for raising food security. However, these practices are associated with loss of soil fertility, loss of soil organic carbon and water pollution due to agro-chemical and excess use of water (Fig 1). Our project investigated the current water resources conditions in Kilombero Valley using the state-of-the-art science hydrologic modelling techniques to determine how water interacts with the landscape and quantify the water resources available. The project, therefore, advocates for inclusive innovative transformation of agriculture and water resource use that can lead to increased yields with less negative environmental impacts.

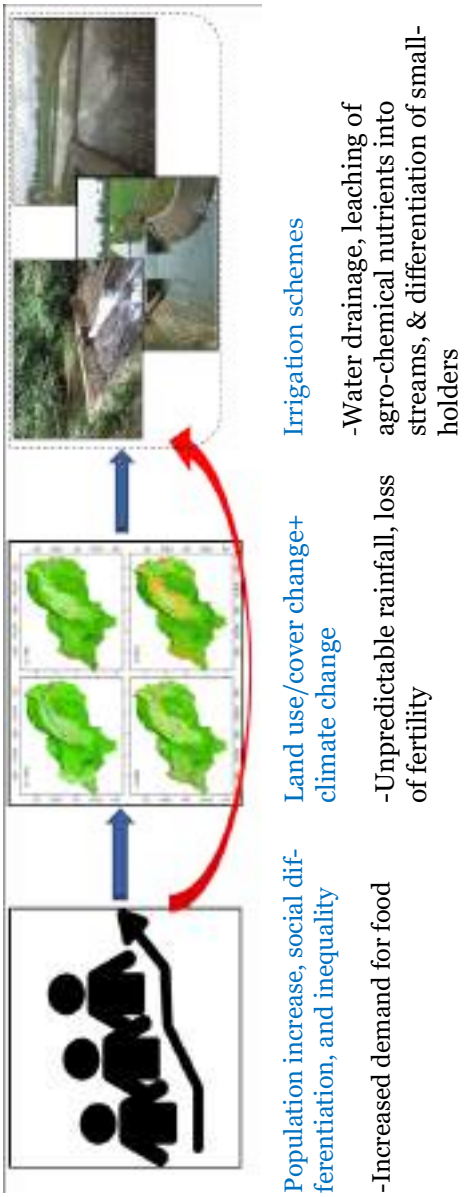

Fig 1: Innovation transformation of agriculture in the context of social differentiation, uneven distribution of resources and rapid population growth.

Key Messages

Agro-Ecological Assessments:

Under this section the study focused on the impacts of agricultural expansion on wetland ecosystem services thusly:

- Large-scale land use change can affect ecosystems beyond recovery, thus encouraging intensive irrigation farming to increase crops production in only a restricted small area and keep the land use mosaic across a large part of the valley.
- Overall, irrigation had a positive effect on Soil Organic Carbon (SOC) and Total Nitrogen (TN) whereas fertilisation positively affected only the TN.
- Higher SOC and TN concentrations promoting increased agricultural production and water holding capacity of soils were found in upper soil layers and decreased with depth for both irrigation and fertilisation treatments.

- On the one hand, water quality across several irrigation schemes and the region were of a good standard under the current management and could support the expansion of irrigation and agricultural practices; on the other hand, increased irrigation and fertilisation without adaptive management could impact on both environmental and human health.
- Based on our findings, we stress that fertilisation and irrigation at small-to-medium amounts could be suitable management practices for enhancing fertility and maintaining production in small-scale farming systems while mitigating global warming by guaranteed carbon storage in long-term.

Socio-Economics &Agro-development:

The SAGCOT initiative calls for investments in both large- and small-scale irrigation ventures in the Kilombero cluster, with more private investments in irrigation encouraged. Under this section, we have studied the socio-economic outcomes of small-to-medium sized public investments in irrigation, established in the 1980s and 1990s for the purpose of improving smallholder rice production. Key messages:

- Public investment in small-to-medium scale smallholder irrigation canals are more inclusive as they build on smallholders' initiatives and allows internal competitions among smallholders without any possibility of being dispossessed off their land by the large-scale private investors.
- Public investments in smallholder irrigation aim to boost productivity and reduce poverty through inclusive growth within the villages. Although irrigation has increased productivity, mainly through the growth of average-income farmers, inclusion of low-income farmers in irrigation development remains a challenge.
- Current agricultural dynamics suggests that there has been increased social differentiation in Kilombero due to both the emergence of wealthier farmers with relatively large tracts of land and of landless labourers who own small areas (under one acre) or no land at all. The challenge is also visible among youths and women who face limited access to land, most of whom have been forced to venture into non-farm activities.
- Extension services and farmer field schools have concentrated mostly in irrigated landscapes compared to non-irrigated ones, which means that these development efforts fail to reach many of the low-income farmers.

Water Resource Assessment

- Mountainous water resources are the main sources of water in the Kilombero Valley Wetland during the dry season. Thus, future water management in the basin should focus on preserving the upland forests.
- Climate prediction suggests the possibility of severe floods in wet seasons and an increasing drought risk in dry seasons. Therefore, the extra water generated during the wet season should be saved for utilisation during the dry season.
- More than 65% of the total mean annual precipitation goes back to the atmosphere as evapotranspiration and this percentage would increase under irrigation and agricultural expansion.
- The future hydrological behaviour of the KV basin, like many other basins in Tanzania, is uncertain due to climate change and agricultural development. In other words, we need to implement adaptive management strategies that can adjust accordingly in response to increased demand and unforeseen changes.

Policy Recommendations

- To secure ecosystem services in the valley, we recommend that Ministry of Agriculture, Livestock and Fisheries and Districts council to encourage investment to be made to intensify small-scale irrigation farming, leaving the remaining part of the valley to recover from degradation.
- The investment in the SAGCOT should be inclusive to boost production and reduce poverty of majority smallholder farmers. Therefore, we recommend SAGCOT and the Ministry of agriculture through the National Irrigation Commission to continue investments within the smallholder sector (both in irrigated and rain-fed agriculture) that build on the knowledge and development potential of small- to medium-size farmers with extension support.
- Combination fertilisation (organic amendment) and irrigation farming should be encouraged at small-to-medium amounts to improve soil fertility and store carbon. This can as well be included in the National Adaptation Programme and Plan for climate change. Also the Ministry of agriculture Livestock and Fisheries must consider upgrading agricultural policy to adopt such a farming management practice.
- Future water allocations by the basin water offices, i.e., for planned expansion of irrigated agriculture and introduction of new schemes, must be based on adaptive management strategies to balance needs across all the users and provide opportunities to incorporate alternative water sources such as rainwater harvesting and groundwater sources instead of solely relying on surface water.

Conclusion

Most of the farmers in the Kilombero Valley use flood irrigation paddy farming while producing diverse food and cash crops—all of which are sensitive to water scarcity. Uncertainties of water security in the coming decades call for a change in the current water-intensive agricultural technologies used in Tanzania. Most irrigated agriculture is conducted with low water-use efficiency due to the use of traditional flood irrigation and unlined canals. Investment in agriculture modernisations that only considers maximising the production potential in the basin could bring about

water scarcity, with basic water needs of other users (such as industry, households and the environment) not met. This calls for more researches on inclusive agricultural development in the context of on-going initiatives to ensure sustainability, from the economic, social and environmental perspectives.

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Sub-Theme 7:
Safe Drinking Water

A Spatial Data-Driven Approach to the Provision of Clean and Safe Drinking Water in Tanzania

By

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Introduction

Access to safe drinking water is a prerequisite for human well-being. In Tanzania, drinking water sources include surface water, rainwater harvesting and groundwater. Due to easy accessibility, affordability and resilience to climate change, groundwater is the only sustainable source of drinking water in many parts of the country in both urban and rural settings. It is estimated that around 76% of water supply is from groundwater sources in Tanzania (Ligate et al., 2021). However, the presence of geogenic contaminants such as arsenic and mercury (Nyanza et al., 2019), fluoride (Mjengera and Mkongo, 2003) and other potentially toxic elements (Tomašek et al., 2021) in groundwater systems significantly challenge access to safe drinking water. In some places, access to ground water is through unregulated self-supply approach posing a high health risk to millions of people, especially in the rural settings (Chávez García Silva et al., 2020; Grönwall and Danert, 2020). The unregulated self-supply approaches include hand dug shallow wells targeting shallow aquifers that are extensive in many parts of the country. Most water supply authorities are not familiar with such sources, hence leading to lack of water quality monitoring data. For economic reasons and accessibility issues, most aquifers, especially the shallow ones, are less or not at all sampled, which leads to inadequate data for understanding the geochemical processes triggering the spatial variability of such contaminants using conventional methods.

This study highlights the importance of advanced approaches such as machine learning and geospatial technologies describing the spatial distribution of geogenic contaminants using limited sampling locations. Using the GIS technology, community perspectives on the drinking water quality status were mapped at the basin level. The commonly pronounced challenges in descending order were salinity, cloudy, and fluoride, which have led to the abandonment of many sources (Ligate et al., 2021). Using spatial analytical methods, new insights on the geogenic contamination by fluoride were generated (Ijumulana et al., 2020). Regional hot and cold spots of fluoride exist within the East African Rift Valley (EARV) regions. The latter consists of potential sources of safe drinking water whereas the former consists of high-risk zones, which require special attention to avoid chronic fluorosis problems (Ijumulana et al, 2021). On the other hand, the regional cold spots consist of drinking water sources with fluoride concentration less than 0.5 mg/L, which is another health hazard in terms of dental caries among communities residing at steep slopes of stratovolcanoes.

Key Messages

The findings of this research are important for the current water policy in the framework of the National Development Vision 2025 (NDV 2025) of Tanzania and the United Nations 2030 agenda (UN 2030 agenda). The achievement of the NDV 2025 highly depends on the practical reality of the national goal in providing clean and safe water to the population within 400 metres of the households. This achievement has both social and economic implications at the individual, national and international level. The national goal is in line with most of the UN 2030 targets of Goal 6 on the Sustainable Development Goals (SDGs) list. The challenge to the achievement of the set targets emanates from the stochastic processes that result in the spatial variability of the contaminants in the aquatic environments.

Spatial distribution of health risks from drinking water with low or high fluoride levels

Despite efforts made to ensure the supply of clean and safe water to the population within 400 metres of the household in naturally contaminated aquatic environments mainly in the EARV regions and volcanic areas, some communities still depend on drinking water sources with fluoride concentration of below 0.5 mg/L and below 1.5 mg/L, which poses a health hazard in terms of dental caries and fluorosis, respectively. In this study, parts of northern Tanzania whose population registers high cases of dental caries and fluorosis, risks were identified and mapped as indicated in figures 1 and 2, respectively. Although aquifers around Mt. Kilimanjaro are usually safe sources of drinking water (Marwa et al., 2018), around 55% of the sources contain fluoride concentration of <0.5 mg/L. Based on the population census data of 2012 (NBS, 2018), around

1 million people are at a significant high risk of suffering dental caries (Figure 1) whereas about 2 million are at a significant high risk of dental, skeletal and crippling fluorosis (Figure 2).

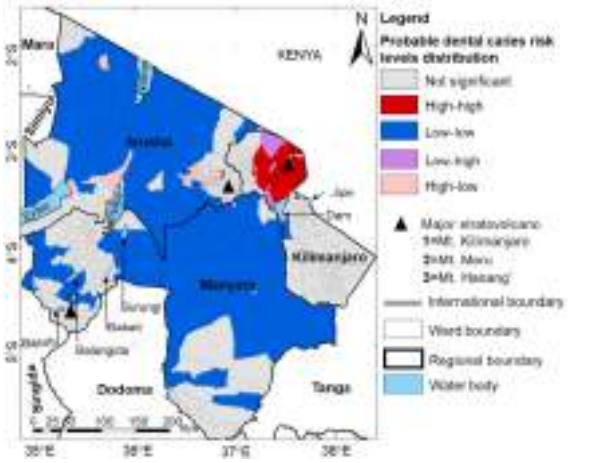

Figure 1: Spatial distribution of probable dental caries risk levels in Kilimanjaro, Arusha and Manyara region (Ijumulana et al., 2021). The health risk levels were mapped at 0.05 significance level (p-value<0.05).

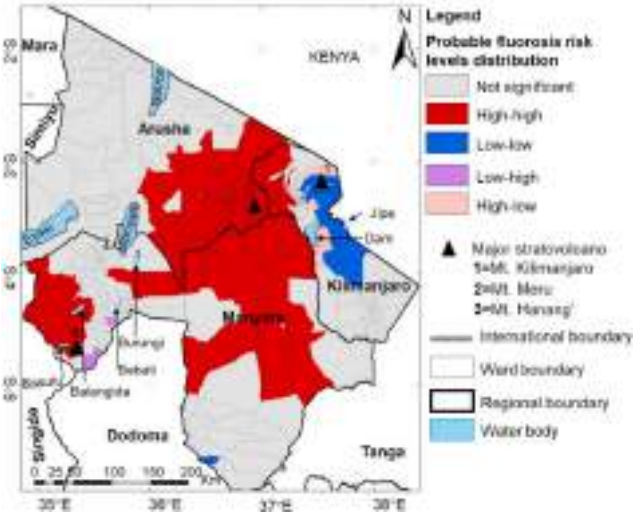

Figure 2: Spatial distribution of probable fluorosis risk levels in Kilimanjaro, Arusha and Manyara region (Ijumulana et al., 2021). The health risk levels were mapped at 0.05 significance level (p-value<0.05)

Spatial variability in fluoride occurrence and potential sources of safe drinking water in naturally contaminated aquatic environments

Fluoride occurrence in drinking water sources is associated with stochastic processes that lead to a high scale of variation resulting in spatial uncertainty when targeting a safe source. This spatial uncertainty cannot be handled using conventional methods. In this study, machine learning approaches were applied to describe the spatial distribution of fluoride concentrations. Specifically, spatial analytical methods and GIS technology were used to identify and map significant zones of safe and unsafe drinking water sources. Figure 3 shows significant patterns representing zones with safe and unsafe water sources. Furthermore, the figure shows significant sources of safe drinking water within the neighbourhood of unsafe sources (Low-high). Similarly, unsafe drinking water sources in the neighbourhood of safe sources (High-low) are indicated. Overall, there are potential sources of safe drinking water in the naturally contaminated aquatic environments. These are indicated as "Low-low" zones on Figure 3. Most of them are clustered around major and minor escarpments of the EARV in the west and east of northern Tanzania, respectively. All the drinking water sources in the "Low-low" zone had fluoride concentrations <1.5 mg/L whereas around 96% in the "High-high" zone had fluoride concentrations of above 1.5 mg/L. Based on these findings, the following drinking water safety plans can be implemented as directed by the WHO:

- The alternative sources for drinking water in geogenically fluoride contaminated environment is enhanced.
- The dilution of high fluoride with low fluoride water sources is enhanced.
- Places where high calcium, magnesium and vitamin C diets are required have been identified as part of mitigating dental caries.
- Places where fluoride removal technologies should be part of the water supply process have been identified. These places include communities within the EARV graben who are far away from the "Low-low" zones.

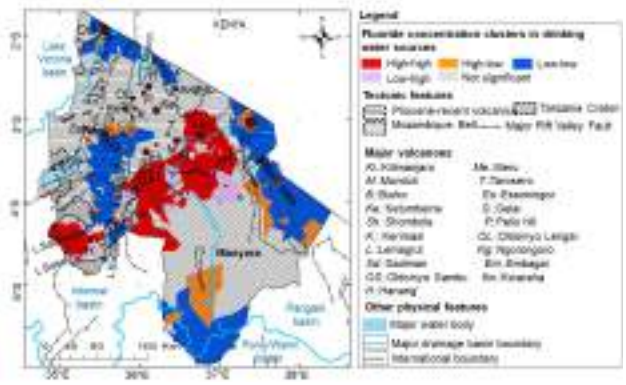

Figure 3: Spatial distribution map of significant regional fluoride hot and cold spots in northern Tanzania (Ijumulana et al. 2020). The significant hot and cold spots were mapped at a 0.05 significance level

Other factors limiting access to clean and safe drinking water in Tanzania

Other factors limiting sustainable access to clean and safe drinking water include salinity, colour and cloudy (Figure 4). These parameters were summarised from the Water Points database created from the national Water Point mapping project of 2013. The water quality status was in Figure 4 was based on the community perspectives. Salinization of water is a leading drinking water quality problem in all drainage basins except the Tanganyika basin whose major problem is cloudy. On the other hand, the change of water colour in basins such as Rufiji, Internal, Pangani, and Lake Victoria deteriorates the aesthetic of water limiting sustainable

access to drinking water. Although not adequately studied, some communities in basins such as Lake Victoria, Rufiji, Tanganyika, and Wami/Ruvu reported high levels of fluoride that have led to the abandonment of some drinking water sources.

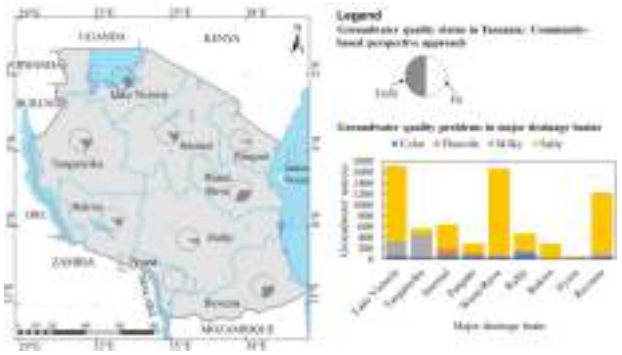

Figure4: Community-based perspective on groundwater quality and potential problems impairing drinking water quality in the national major drainage basins of Tanzania (Ligate et al., 2021).

Recommendations

When dealing with geogenic fluoride contamination, there is no universal solution to the problem. As section 4.2 indicates, alternative sources with fluoride concentrations of between 0.5 and 1.5 mg/L in the neighbourhood of > 1.5 mg/L can be an affordable and sustainable source of drinking water, especially in rural areas found in arid and semi-arid type of climate within the EARV graben. Likewise, the mixing of water with low (<0.5 mg/L) and that with high (>1.5 mg/L) fluoride concentrations is a suitable option for communities residing around the stratovolcanoes within the EARV graben. To implement these options effectively, the following strategies are recommended:

- The water supply authorities should establish fluoride monitoring networks in the significant patterns identified in this study. The effects of climate variability should be studied over years while testing the applicability of the non-chemical solutions as recommended by WHO.
- The water supply authorities should focus on improving the current drinking water quality database by introducing intermediate sampling points rather than depending on the current drinking water sources. To minimise the cost, we encourage capacity-building of the technical staff at each water quality laboratory. The training should focus on advanced methods such as integrated spatial analysis and GIS technology used in this study.
- The water supply authorities should consider the regulation of the self-supply practice of groundwater, which is an alarming health hazard in the naturally contaminated drinking water sources.
- The water supply authorities should reflect on the enforcement of the regulations regarding the drilling permits in zones where there are no alternative sources of drinking water. In such circumstances, fluoride removal technologies should be an integral part of the supply to avoid later health risks.
- The water supply authorities should focus on testing sources of drinking water all over the nine basins, not only fluoride but also other parameters that are of health concern.

Conclusion

This study has established that there is no universal solution to the natural fluoride contamination of drinking water sources. The selection of the best option requires adequate investigation using advanced methods such as machine learning, artificial intelligence and deed learning that consider the location of each source. By so doing, the cost of sampling will be minimised and patterns of interest shall be characterised which will guide the option for health risks mitigation. Likewise, the water supply authorities should focus on testing all the drinking water sources and quantify elements of health concern for better formulation of health-based targets.

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Use of Local Available Mineral Materials – Bauxite, Gypsum and Magnesite in Tanzania for Arsenic Removal from Drinking Water Sources

By

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Issue:

Levels of arsenic contamination in drinking water sources around gold mining areas in Tanzania ranges from 10ppb to 300ppb, which is above the WHO limits. This high level is a health hazard for populations living in those areas as arsenic contamination in drinking water is associated with cancer (skin, lung and internal organs), cardiovascular diseases, neuropathy diseases, hormonal imbalance, foetal loss and premature births. Indeed, empirical studies suggest that high rates of those diseases are partly caused by arsenic even at below 10ppb exposure level, hence the urgent need to address this problem. Despite the local materials available being proven to be effective in the removal of arsenic from 78% to 99% (e.g., bauxite, gypsum, and magnesite), local communities are unaware of the arsenic contamination in drinking water as well as the simple technology that could be used in solving the problem. Meanwhile, the government has not made sufficient effort to promote the use of local materials in reducing arsenic contamination from drinking water sources and has not adopted technology as a tool for solving this problem.

Findings:

- Tanzania recently reported to have arsenic levels of above the WHO-recommended limit of 10ppb around gold mining areas (Mnali, 1999; Kassenga and Mato, 2008; Nyanza et al., 2014; Lucca, 2017).
- Worldwide, the elevated levels of arsenic were reported to pose health hazards in Argentina, Bangladesh, Chile, India, Mexico, Mongolia, Nepal, New Zealand, Thailand, Taiwan, Turkey and Vietnam.
- Arsenic in Tanzania (Geita and Mara) ranges from 10ppb to 300ppb but the society is not aware of this lurking danger in water.
- Health effects around mining areas, Geita and Mara are not well-documented, but skin infection was observed among labourers, especially women who wash gold ores by hands. Also, a high number of cancer patients at Ocean Road Institute of Cancer are from Lake Victoria Basin.
- There is a need to develop cheaper, efficient arsenic removal materials to secure the society from arsenic contamination in drinking water sources.
- This project aims to prepare local materials such asbauxite, gypsum, and magnesite, for removing arsenic from drinking water. These local materials were then tested at laboratory scale to evaluate their capacity in arsenic absorption from water.

- Tanzania has plenty of land of about 885,800 sq.km, which simplifies the availability of minerals such as bauxite, gypsum, hematite and magnesite for drinking water filtration purposes. Materials were previously applied for fluoride removal in Arusha and had produced promising results.
- Adding efficiency to the efficacy of the materials entailed sieving to smaller size below 0.3mm and calcination on the furnace at 500 ° for 4hours. Materials work efficiently at initial neutral pH 7.
- The removal process on surface of the material takes place when arsenic species displace hydroxyl or oxide group to form insoluble surfaces (as indicated in equation 1 to 4). In natural water, As^{V} existed as $H_2AsO^-_4$ and As^{III} as H_3AsO_3.

$$Al_2O_3 + 2HAsO_4^{2-} \rightarrow 2AlOAsO_4^{2-} + 2OH^- \quad (1)$$

$$CaSO_4^{2-} + HAsO_4^{2-} \rightarrow CaHAsO_4^{2-} + SO_4^{2-} \quad (2)$$

$$MgCO_3 + AsO_4^{3-} \rightarrow MgAsO_4^{3-} + CO_3^- \quad (3)$$

$$FeOOH + H_2AsO_4^- + 3H^+ \rightarrow FeH_2AsO_4 + 2H_2O \quad (4)$$

- Magnesite that is calcined shows the removal of arsenic of about 99% at initial concentration of 1000ppb and neutral pH 7. Arsenic was lowered to below 1 ppb when a high dosage of magnesite of 10 g was added to 100 ml.
- Magnesite has high influence on other materials such as bauxite and gypsum when it comes to arsenic adsorption particularly when it is mixed in ratios.
- The calcined bauxite shows arsenic removal of about 99% at pH 7, initial concentration 1000 ppb. Arsenic was lowered to below 1ppb.
- Calcined gypsum shows arsenic removal of about 99% at neutral pH with initial concentration of 1000 ppb. Arsenic was lowered to 7.6 ppb
- Re-use of the spent materials is done through contact with 0.1 M NaOH solution even though arsenic was covalently bonded to magnesite.
- The treatment plant produces 20 litres per day arsenic free water which can accommodate 10 people per day if they will drink 2 litres each.
- The lifetime of material is six months before replacement and can be reused after cleaning with a high concentration of NaOH solution.

Recommendation:

- Local material tested was efficient at removing arsenic from drinking water.
- More campaign is required among society members to create awareness on arsenic contamination in drinking water sources around gold mining areas in Geita and Mara.
- Government support is required to train people on how to prepare and use local materials to clean water at the household level.
- Local, cheaper materials in Tanzania must be promoted to reduce the cost of arsenic removal from drinking water sources.
- More efficient way of preparing bauxite, gypsum,and magnesite for arsenic removal should be innovated with time.

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Sub-Theme 8:
Sanitation Management

Integrating Char Briquettes Production in Faecal Sludge Treatment Plants

By

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Overview

Production of FS char briquettes in urban settings of Tanzania such as Dar es Salaam city is a viable solution for faecal sludge management, as it promotes resource recovery than safe disposal of the material. The briquettes produced have high potential of replacing charcoal demand. For example, in Dar es Salaam, the briquettes can replace more than 8% of charcoal demand. About 14% of cooks in the city rejected using FS char briquettes due to socio-cultural norms associated with FS that consider it to be unhygienic and dirty. The remaining 86% respondents, on the other hand, suggested that the price and quality of the briquettes produced is the determining factor for its usability. Overall, the production of FS char briquettes constitute a reliable alternative energy source intervention. However, the intervention demands urban water supply and sanitation authorities to promote the construction of more FS dewatering plants, and fund local enterprises to engage in the FS char briquettes production business.

Background

Charcoal is a commonly used energy source for cooking in urban settings of Tanzania. It accounts for about 79.3% of the total cooking energy use (NBS and REA, 2017). For example, the daily charcoal importation from regions of Tanzania to Dar es Salaam city is about 336 tonnes. The amount accounts for about 30% of the country's daily charcoal consumption (Mwema, 2015). Charcoal production is directly linked to deforestation and, hence, global warming that leads to the reduction of rains. Rain facilitates agriculture, which is the backbone of Tanzania's economy (Drechsel *et al*., 2011; Mwema, 2015). Production of FS char briquettes as an affordable alternative cooking energy source for Dar es Salaam city might be an adequate and sustainable intervention. The proposed intervention aims to reduce the daily charcoal importation to Dar es Salaam city, hence saving the environment and boosting the economy of users.

Faecal sludge chat briquettes can be produced from faecal sludge originating from onsite sanitation containment. In fact, more than 90% of Dar es Salaam's population relies on onsite sanitation containments (pit-latrines and septic tanks) that contributes to the generation of massive amount of faecal sludge (Seleman *et al.,* 2020). Nevertheless, about 57% of the faecal sludge generated is not safely managed, and at times ends up being discharged directly into water receptors (Brandes *et al.,* 2015; Jenkins *et al.,* 2014). The unsafe management of faecal sludge is directly linked to insufficient availability of FS treatment plants. The current treatment plant is the wastewater treatment system (WSP) that was not principally designed to treat FS but wastewater. As a result, the ponds, especially the anaerobic ponds, frequently get filled, hence requiring reservation of a high operational and maintenance budget (Brandes *et al.,* 2015). Recently, an emphasis is on encouraging dewatering of FS as the best approach to simplifying and attaining adequate treatment of FS (CAWST and Sandec, 2016; Klingel *et al.,* 2002). This approach facilitates the generation of a high amount of dry FS that could be utilised in FS char briquette production.

Key Findings

Technical opportunities and challenges of adopting use of FS char briquettes

Briquettes produced by blending FS char and coffee husks char in a ratio of 70%:30% (Figure 1) have half energy quality as charcoal (Table 1).

Table 1: Quality between FS char briquettes and charcoal

Energy Source	Energy quality (MJ/kg)	Ash (%)	Source
FS char briquettes	13	44	This study
Charcoal	26	< 5	Gold *et al.* (2016)

Figure 1: FS char briquettes

Though FS char briquettes have less energy quality and higher ash content than charcoal, they are reliable and sustainable products so long as people defecate the raw material for making briquettes (dry FS). On the other hand, charcoal has higher energy quality and less ash of charcoal, yet its continued is associated with deforestation that leads to global warming and reduction of rains (Drechsel *et al*., 2011; Mwema, 2015). Results in Table 1 indicate that replacing 1 kg of charcoal requires 2kg of FS char briquettes. Taking Dar es Salaam city as a case study, the 2317 m^3/day of FS collected in 2017 had a potential of producing 55.7 tonnes of FS char briquettes that would reduce the city's daily charcoal demand by 8%.

Although there is potential of producing FS char briquettes in urban areas of Tanzania, there are insufficient number of FS dewatering plants to generate the raw material (dry FS) for char briquettes production. For example, in Dar es Salaam, there are only four (4) operating DEWATS, that serves only four (4) wards, leaving 69 wards unserved. The unserved population directly uses WSPs, which results in frequent filling out of the ponds, leading to high operational and maintenance costs.

Socio-cultural acceptance of FS char briquettes

About 86% of cooks in Dar es Salaam city had a positive response to the use of FS char briquettes. The remaining 14% rejected their usage. Those who accepted to use the product claimed that the fuel did not differ much with charcoal in terms of colour; moreover, they loved it since it has a definite shape (cylindrical with a hole). So, they assumed it to be safe for use, just as charcoal. The only determining factor that trigger their selection for a cooking energy source is mainly the cost and other quality parameters of fuel, which are availability, ash content, smoke, ignition, longevity and heaviness (Figure 2). On the other hand, those who rejected the use of briquettes claimed that they could not use the energy source because it was made using dirty and unhygienic materials (FS).

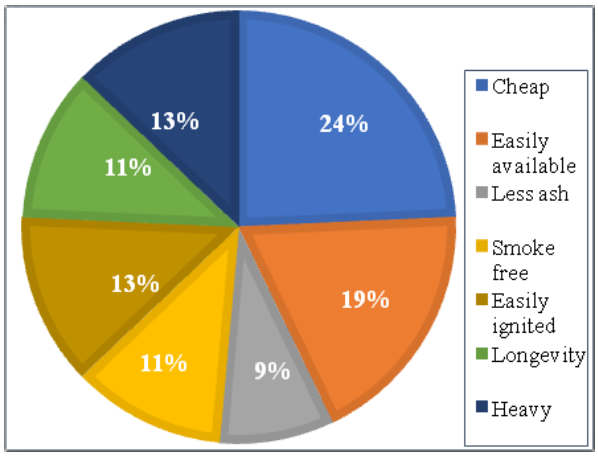

Figure 2: Ranking of criteria that determines the choice of fuel for use

Financial and safety viability of adopting FS char briquettes

A complete set of manually operated FS char briquettes machines is cheaper than the electric (motorised) set. The choice of the type of set of machines for use has implications for determining the price of FS char briquettes, as Table 2 illustrates:

Table 2: Investment and pricing of FS char briquettes

Type of machine	Investment cost (Tsh)	Price of FS char briquettes (Tsh)	Price of char-coal (Tsh)
Manually operated set	10 – 20 million	10 @kg	900 @kg
Electric (motorised) set	40 – 50 million	300 @kg	900 @kg

Although there is financial viability in implementing FS char briquettes projects in urban areas such as Dar es Salaam city, the safety guidelines to be followed by people involved in FS collection, dewatering and carbonisation are missing. As a result, the stakeholders involved in the sector might be exposed to harm, that is, microbial contamination from both un-dewatered and dewatered FS, high temperature exposure, and smoke inhalation during the carbonisation of dry FS.

Policy Implications

Results from the study imply that the unavailability of resource recovery units that turn dry faecal sludge (FS) into cooking energy (FS char-briquettes) at the FS treatment plants is due to unavailability of funds and local enterprises in the sector. Moreover, the current sanitation policy focuses on advocating for adequate sanitation facilities and treatment of FS offsite (UNICEF and WHO, 2019). Yet, the policy is not specific to FS resource recovery interventions at the treatment plants, hence encouraging more of safe disposal that leads to loss of otherwise recoverable resources. Also, less funding and motivation for local enterprises dedicated to FS char-briquettes production at the treatment plants might be an obstacle to achieving adequate and sustainable sanitation for all by 2030.

Recommendations

Urban water supply and sanitation authorities such as DAWASA should promote the construction of more FS dewatering plants. This promotion should be done by funding the design and construction of plants. Furthermore, the authorities should fund and encourage local enterprises to engage in the FS char briquettes production business.

The urban water supply and sanitation authorities together with non-governmental organisation (NGOs) directly involved in faecal sludge management should promote the FS char briquettes production and upscale community awareness on the safety and reliability of FS char briquettes as an alternative cooking energy source.

Furthermore, the Ministry of Water should collaborate with the Ministry of Health to develop and institute safety guidelines that stakeholders directly involved in FS collection, dewatering, carbonisation and production of FS char briquettes can follow. These guidelines will facilitate the hygienic management of FS and promote safe production of FS char briquettes.

Conclusion

There is insufficient number of FS dewatering plants in the urban settings of Tanzania. The plants offer dry FS, which is the raw material for FS char briquette production. Hence, FS char briquettes production needs to be integrated in all FS treatment plants. The integration will offer a reliable alternative cooking energy source (FS char briquettes) to charcoal. Furthermore, funds and production of safety guidelines should be available to local enterprises motivated to establish FS char briquettes production businesses.

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Improving the Design and Performance of Faecal Sludge Dewaterability

By

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Background

Main objectives for dewatering facilities are to reduce time for dewatering and increase the amount of solids (%TS) in drying faecal sludge (Gold *et al*.,2016 and Semiyaga *et al*., 2017). This dry faecal sludge is potential material for resource recovery. Therefore, proper design and efficiency of FS treatment facilities for dewatering depend on accurate knowledge of FS dewaterability. Knowing FS dewaterability while still in containment can contribute to informed designing and of appropriate selection of FS treatment technologies. Many of the existing dewatering facilities might fail to reduce dewatering time and increase the amount of solids in dry faecal sludge (%TS in dry cakes) for FS from different containments and seasons. For example, the pilot dewatering facility, which constructed at the University Dar es Salaam could reduce the time for dewater FS with low strength as compared with FS with high strength. This might be because designing of this pilot facility does not consider variability of FS dewaterability. Despite numerous studies on FS dewaterability (Gold et al., 2016; Semiyaga et al., 2017), the variability in dewaterbility of FS across different types of OSS containments and season has not been documented. To speed up the time spent for FS dewatering, local conditioners must be applied. Moringa *Oleifera* and *Jatropha Curcas* seeds are local conditioners recommended for that purpose since they are locally available and help to improve the performance of dewatering facility (Gold *et al*., 2016). These seeds contain proteins, which can improve dewaterability of FS especially in reducing dewatering time. However, the comparison on their efficient in improving FS dewaterability is yet presented. This policy brief presents findings on the variability of FS dewaterability across the different containments in different s and compares the efficiency of *Moringa Oleifera* and *Jatropha Curcas* in improving FS dewatering time.

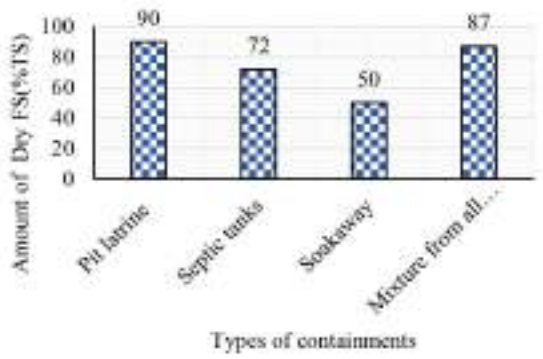
Figure 1: Dewatering facility located at University of Dar es salaam

The findings indicate that FS from pit-latrine took longer to dewater (higher CST values) though it produced large contents of %TS in cakes. Moreover, findings indicate that dewatering time parameter in PT is higher in the dry than in the rainy season. Using this facility for FS with high strength needs to be diluted with FS with very low strength or diluted with water to improve dewatering time. Meanwhile, at same time dilute FS to result in low amount of solids in dry faecal sludge (%TS in dry cakes). For a superior performance of dewatering facilities, the DCOM manual should be updated on the variability of FS dewaterability across different containments and in diverse seasons.

Key Findings

FS dewaterability varies across different containments

The findings indicate that FS from pit-latrine took longer to dewater (higher CST values) compared to other sources (Fig 2), through large %TS in cakes were noted in the PT containment (Fig.2). The differences in dewatering performance between PT and other sources is likely related to the filtration of water through the wall of the pit-latrine. Therefore, using the existing facility for dewatering FS from pit--latrine takes a long time but high %TS in dry cakes could be produced.



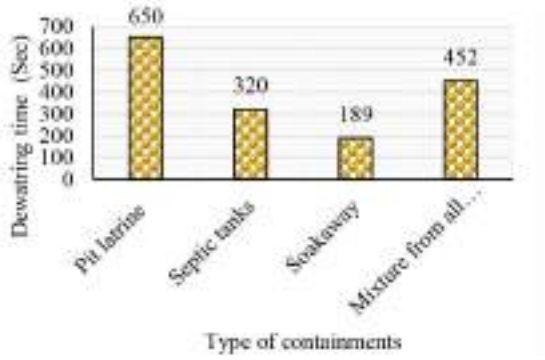


Figure 2: Variability of dewatering time and amount of solids in dry cake across different containments

FS dewaterability varies with Season within the containments

The results indicate that dewatering time parameter in PT is higher in the dry than during the rainy season (Fig. 3). However, PT observed to have high amount of % TS in the dry season compare with other containments (Fig. 3). This might be due to loss of water through the wall of the PT, hence leading to high concentrations of TS in the PT and contributing to clogging of filters and pores within the sludge cake, which results in slower dewatering.

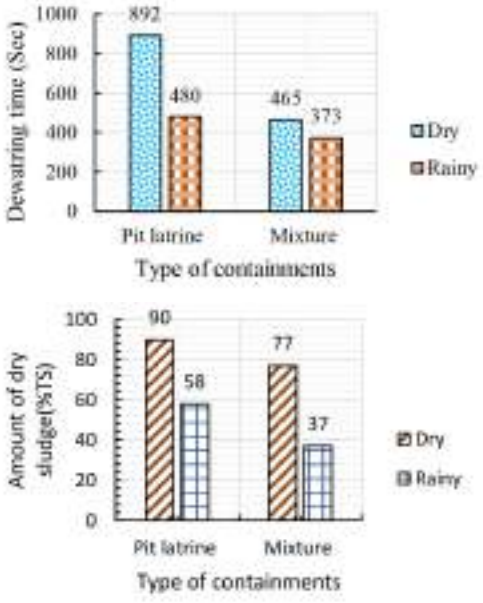


Figure 3: Seasonal variability of dewatering time and amount of solids in dry season

Jatropha Curcas improves FS dewatering time more than Moringa Oleifera

The findings indicate that *Moringa Oleifera* takes a longer period to improve dewatering of FS as than *Jatropha Curcas* (fig.4). This might be due to higher amount of protein present in *Jatropha Curcas* seeds than in *Moringa Oleifera*.

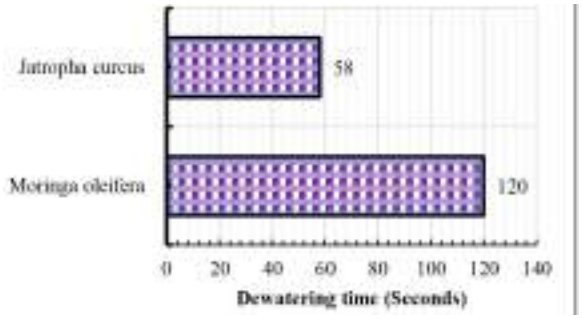


*Figure 4: Time taken when applying **Moringa Oleifera** and **Jatropha curcas** in FS dewatering*

Policy Implications

Prominence in variation of FS dewaterability across the different containments and seasons before designing and during the performance of dewatering facility should prioritised. Also, *Jatropha Curcas* is more effective in improving performance of dewatering facilities than *Moringa Oleifera* should be place in order

Recommendations

The Ministry of Water should update the design, construction, supervision, operation and maintenance (DCOM) manual to include data on the variability of FS dewaterability across different containments and seasons.

Moreover, the Ministry of Water should update DCOM to include the use of *Jatropha curcas* in improving the performance of dewatering facilities.

Concluding Statement

Variability of FS characteristics is evident in different OSS containments. During the dry season pit-latrine contains FS with substantial amounts of TS settled with a high percentage of Total solids in dry sludge, which are favourable for resource recovery. Also, *Jatropha curcas* seeds improve dewatering time of FS better than *Moringa Oleifera* seeds.

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Advancing and Promoting Faecal Sludge-Derived Products Uptake at Community Level

By

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Introduction

Over 90% of the population in Dar es Salaam relies on on-site sanitation systems (OSSs) with only 43% of the generated faecal sludge (FS) safely treated and the remaining 57% is discarded directly into the environment (Brandes et al., 2015). The FS in Dar es Salaam is currently co-treated with wastewater through designated Waste stabilisation ponds (WSPs) which however in most cases are overloaded and not performing optimally (*ibid.*). Following the sanitation service chain, steps of FS management are finalised by treating FS for either disposal or recovery and reuse. Resource recovery and re-use (RRR), as one of the strategies that provide sustainable alternatives, can be applied in faecal sludge management as an incentivised approach to overcoming challenges.

Few faecal sludge RRR (FS-RRR) implementations have been piloted in Dar es Salaam to-date. One example was an ecological sanitation which involved constructed urine-diversion toilets to provide alternative sanitation solutions in unplanned settlements for recovering the urine for agriculture (McGranahan, 2015). However, the failures of the adopted of FS-RRR options soon after being piloted are well-documented (JMP, 2018). To obtain effective FS-RRR adoption options, community engagement, people's awareness, opinions and attitudes to the implementation are important factors for making adoption decisions (Meena et al., 2012). Despite various efforts made to promote the concept of FS-RRR through piloting projects in Dar es Salaam, there is limited information available to stakeholders on advancing and promoting the uptake of FS-RRR end-products.

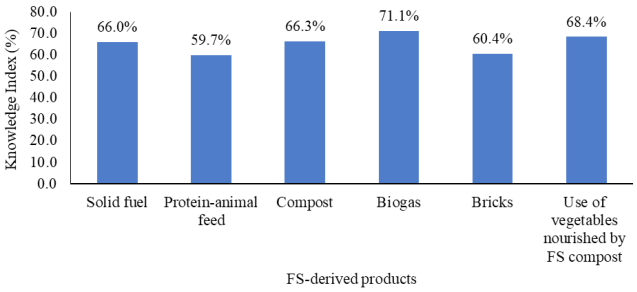
The aim of this policy brief is to inform stakeholders on the current residents' knowledge and attitudes towards faecal sludge-derived products together with practices regarding the faecal sludge RRR in Dar es Salaam in a bid to promote the use of faecal sludge-derived products.

Summary of key messages

- Limited community awareness on FS resource recovery
- Negative attitudes towards most of the FS end-products
- Low acceptance of FS-derived products quality
- Inadequate O&M of RR treatment facilities

Limited community awareness on FS resource recovery

Community awareness, which was determined using knowledge index categories, indicated that all residents fall in the moderate knowledge level on FS-derived products as demonstrated in Figure 1. It is highly likely that the reasons for such moderate knowledge are lack of community training and awareness-raising campaigns coupled with limited experience, which also demoralises them in taking care of any pilot project implemented in their respective settlements.



Knowledge index thresholds(High knowledge >80%; Moderate knowledge 50-79%; Low knowledge <50%)

Figure 1. *Residents' Knowledge index (%) for each potential FS-RRR derived product*

Negative attitudes towards most of FS end-products

Photos of FS-derived products were used to analyse the community acceptance. The products are biogas, solid fuel, compost, protein for animal feed, construction material and vegetables. Only 4% of the participants expressed the acceptance of products with positive attitude observed towards only solid fuel. Edible products such as poultry meat and vegetables were the lowest-ranked than non-edible products due to culture, norms, taboos, religious beliefs restrictions as barriers towards the use FS products in connection with health concerns. Table 1 presents a summary of the attitude index categories to the 6 products presented:

Table 1. Participants' attitude index towards FS-derived products

FS-derived product	Attitude Index (%)	Attitude Category
Vegetables	9.4	Negative
Compost	63.8	Neutral
Poultry meat	6.0	Negative
Biogas	45.7	Negative
Solid fuel	96.6	Positive
Bricks	6.0	Negative

Low acceptance of FS-derived products quality

The low acceptance of products was also influenced by failure in quality assurance of FS RRR products for consumers' safety and health because the products had not yet passed through any standards and regulation. The '*product quality*' was the most mentioned factor of concern. Almost half (49%) of the participants mentioned it as an influential factor when it comes to products acceptance. Table 2 presents percentage of participants with their ranked factors for product acceptance:

Table 2. Factors influencing products' acceptance

Acceptance factor	Percentage of respondents (%)	Rank
Cost	47	2
Quality of the product	49	1
Smell of the product	34	6
Religious restrictions	42	4
Disgust feelings	36	5
Health concern	45	3

Inadequate O&M of RR treatment facilities

The FS treatment facilities that promote resource recovery were limited in terms of number and capacity. Only 4 Decentralised wastewater treatment systems (DEWATS) had been implemented at the pilot/research stage in Dar es Salaam even though water and biogas recovery had yet to be fully realised (MoW, 2020). Moreover, the available 1 vermicompost toilet and 3 Ecosan toilets exist even though they were not performing properly as designed soon after being implemented mainly due to inadequate O&M guidelines, regulations and standards for guiding trained operators (Borda-Africa, 2017). Findings from a recent monitoring study revealed that 67% of the DEWATS built showed performance problems (MoW, 2020)as Figure 2 illustrates:

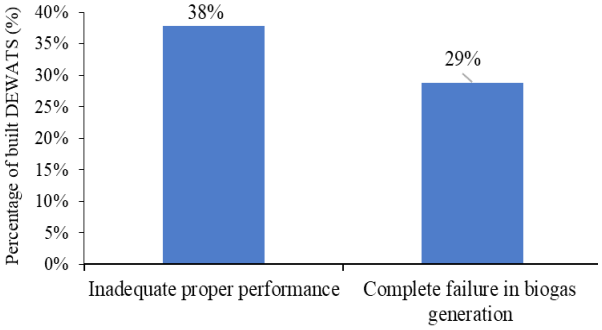


Figure 2. *Performance challenges observed from 67% of built DEWATS in the country(MoW, 2020)*

Policy implications

The potential of FS resource recovery and possibilities are evident. However, there is lack of knowledge and inadequate operation and maintenance of RR treatment facilities, which result in low implementation of resource recovery practices. Negative attitude expressed by residents towards FS-derived products also influence the consumers' low acceptance. To promote the uptake of end-products, there is an urgent need for the following policy recommendations to be addressed.

Policy Recommendations

To plan for community awareness creation

- Municipalities, environmental committees at Ward offices in collaboration with other committees responsible for health should plan and conduct frequent community training, awareness creation and rising programmes.

To develop product standards to ensure quality control

- National certification boards such as the Tanzania Bureau of Standards (TBS) must develop standards for faecal sludge resource recovery products.

To adopt and adapt O&M manuals

- Operators should adopt and adapt O&M manuals for FS treatment infrastructure for resource recovery procedures.

Conclusion

There is relatively low knowledge on the faecal sludge resource recovery concept among residents, mainly because of lack of awareness. Of all the FS-RRR products, only solid fuel was positively accepted. The negative attitudes towards other potential FS-derived products are mainly due to factors such as socio-cultural dimensions such as disgust, product quality and religious restrictions. Moreover, there is limited operation and maintenance guidelines to support the implementation of FS-RRR and use of products such as standards and regulations. To improve the residents' awareness, attitude, and practices in the field of FS-RRR, emphasis should be placed to training, and awareness-raising campaigns. The existing operation and maintenance manuals on sanitation should be reviewed to include guidelines and regulations on faecal sludge RR treatment facilities and implementations. Further, the standards for

FS-derived products ought to be developed to safeguard the quality to consumers.

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Towards Safe Pit Emptying in Unplanned Urban Settlements

By

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Summary

Safe pit emptying is crucial for both the public and the environment as well as for attaining the goals of adequate universal sanitation by 2030. However, the toilet design feature and faecal sludge characteristics play key role in facilitating safe pit emptying. Promoting inclusion of design features such as lining, strong slab, access point for emptying and confining solid waste to pits is key to achieving safe pit emptying. Guidelines for building toilets should, therefore, be updated to emphasise pit lining, use of strong slab cover, and provision of access points for safe emptying.

Background

In unplanned urban settlements, where over 70% of the urban population in Tanzania live, emptying pits is the only action to take to solve the problem of filled up toilets owing to the lack of space for excavation of new pits (Strande et al., 2014). Nevertheless, achieving safe emptying of sewage pits hand-pumps and special vacuum trucks has remained a challenge. Unsafe emptying using manual hand tools, pit diversion or releasing of a portion of faecal sludge through flood waters is a common practice (Thye et al., 2011). Globally, data that estimate the problem of unsafe emptying is rare; however, some cities have attempted to quantify the problem at hand (UNICEF & WHO, 2019)sanitation and hygiene targets within the Sustainable Development Goals (SDGs. In Dar es Salaam, for example, 23.7% of the filled up toilets are emptied using unsafe methods, practices that risk public health and environmental pollution (Seleman et al., 2020).

Studies indicate that, reliance on unsafe emptying methods is associated with Contextual, Psycho-social and Technological factors (Seleman et al., 2020). Plot physical inaccessibility, outdated laws that stipulate low penalties are some of the contextual factors. Perceived inability to control unhygienic emptying among community members and the lack of shame among those undertaking unhygienic emptying are key psycho-social factors. Furthermore, technological factors contributing to unsafe emptying are linked to the weakness in existing emptying technologies and general scepticism about the performance of manual hand pumps.

Design features of the toilets and characteristics of accumulated faecal sludge are also linked to reliance on unsafe emptying (Strande et al., 2014). Toilet design features such as lack of pit lining render such pits unstable for emptying; weak slab cover is hazardous to emptying, especially when using manual equipment such as Gulper. Other design features such as key hole size and access hole to pits discourage emptying using safe methods owing to the need to dismantle the slab to gain access to the pit, which is also time-consuming and escalates the cost (Chiposa et al., 2017; Morgan, 2013). Thick faecal sludge, a common characteristic in dry toilets such as Ventilated Pit Latrines and Traditional Pit Latrines is hard to pump out using vacuum tankers or hand pumps (Boesch and Shertenleid, 1985). Yet, the presence of solid wastes in pits interferes with pumping process and, consequently, increases emptying charges. Recently, emphasis is on improving the toilet design as one way of achieving access to adequate sanitation for all by 2030 (UNICEF & WHO, 2019)sanitation and hygiene targets within the Sustainable Development Goals (SDGs. This intent can benefit from improvements in the toilet design aimed to promote features that facilitate emptying. This brief, therefore, reports findings from a study that was conducted in three unplanned settlements of Kipawa, Manzese and Keko in Dar es Salaam city on the characteristics of toilet facilities and their potential for safe emptying . The data was collected using a house survey and analysis of faecal sludge.

Key messages

Some toilets lack key design features for safe emptying

Presence of access point for desludging, lining pit and strong slab are key features that support safe emptying of sewage pits. In the study areas, half of the toilets lacked access points for such emptying (Figure 1). Most of the toilets that lacked access points are those whose pits had been built right under the superstructure (direct to the pit toilet) than those whose pits were off-set (P = 0.000). However, because of space limitation, toilets that are directly above the pit are the most preferred in unplanned urban settlement than the off-set ones.

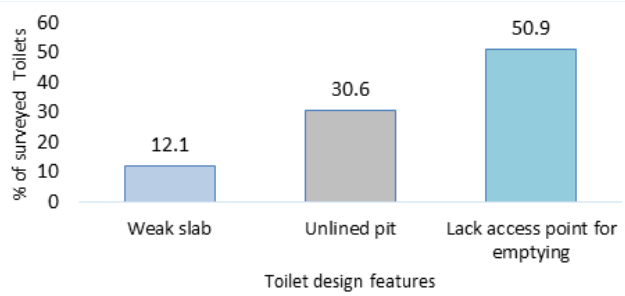

Figure 1: Characteristics of toilet facilities

Figure 1 further shows that one-third of the toilet facilities surveyed lacked proper lining. In unplanned urban settlements is Dar es Salaam, soil is generally unstable hence necessitating lining of the pits (Brandes et al., 2015). However, the lining is usually partial with the bottom part being left un-sealed. Unsealed pit bottoms drain water away, especially during the dry season.

Faecal sludge in some toilets cannot be pumped

Nearly half of the toilets contain faecal sludge that cannot be pumped out using either a hand pump or vacuum tankers (Fig.2). Faecal sludge in toilets that cannot be pumped out have low moisture content and low volatile solids (Boesch & Shertenleid, 1985). Low moisture content in pits results from the restriction of entry of water into the pit or water in the pit is allowed to percolate away. In the pit, water can be introduced either by flushing or anal cleansing with water. In the study areas, the use of water for anal cleansing is common, hence the toilet with low water content loses water through percolation. Paradoxically, the process of leaching away water from the sewage pits is advantageous among some residents with filled up toilets because it slightly shrinks faecal sludge and leaves a void between the slab and faecal sludge level they can use for some more months without worrying about emptying, especially in largely inaccessible and confined spaces. The lining of toilet pit fully limits the percolation of water, rendering faecal sludge pump-able.

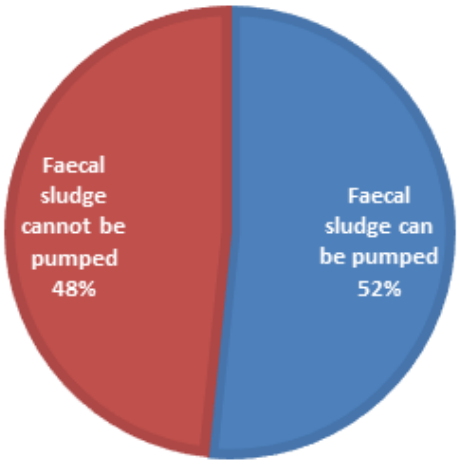

Figure 2: Distribution of faecal sludge based on ability to pump it out

Moreover, the low likelihood of a toilet to be emptied is caused by low amount of volatile solids. Lower amount of volatile solid indicates that much of the organic part of faecal sludge has decomposed. This process occurs when the toilet has stayed with faecal sludge for at least five years without its being emptied (Peal et al., 2014)desk-based study assesses the institutional context and the outcome in terms of the amount of fecal sludge safely managed in each city. A range of cities was included in the review, all in low- and middle-income countries. None of the cities studied managed fecal sludge effectively, although performance varied. Where cities are seeking to address fecal sludge challenges the solutions are, at best, only partial, with a

focus on sewerage which serves a small minority in most cases. FSM requires strong city-level oversight and an enabling environment that drives coordinated actions along the sanitation service chain; thiswas largely absentin the citiesstudied. Based on the findingsofthe reviewa typology of cities was developed to aid the identification of key interventions to improve FSM service delivery. Additional work is recommended to further improve the tools used in this study in order to enable better understanding of the FSM challenges and identify appropriate operational solutions.","author":[{"dropping-particle":"","family":"Peal","given":"Andy","non-dropping-particle":"","parse-names":false,"suffix":""},{"dropping-particle":"","family":"Evans","given":"Barbara","non-dropping-particle":"","parse-names":false,"suffix":""},{"dropping-particle":"","family":"Blackett","given":"Isabel","non-dropping-particle":"","parse-names":false,"suffix":""},{"dropping-particle":"","family":"Hawkins","given":"Peter","non-dropping-particle":"","parse-names":false,"suffix":""},{"dropping-particle":"","family":"Heymans","given":"Chris","non-dropping-particle":"","parse-names":false,"suffix":""}],"container-title":"Journal of Water Sanitation and Hygiene for Development","id":"ITEM-1","issue":"4","issued":{"date-parts":[["2014"]]},"page":"563-575","title":"Fecal sludge management: A comparative analysis of 12 cities","type":"article-journal","volume":"4"},"uris":["http://www.mendeley.com/documents/?uuid=79ccecbe-06d0-4d34-a8e9-15e9f2051473"]}],"mendeley":{"formattedCitation":"(Peal, Evans, Blackett, Hawkins, & Heymans, 2014.

Solid wastes are still common in toilet facilities

Nearly all the toilet facilities surveyed contained solid wastes. In the study areas, one toilet facility may contain as much as 760g of dry solid wastes in 20 L of faecal sludge. Common items thrown into pits include menstrual hygiene products, pieces of cloths, bathing brushes, underwear, sponges, stones, hair, plastic bottles, coconut husks, razor-blades, tooth-brushes and plastic bags (Plate 1). Furthermore, in the areas surveyed, the amount of solid waste in traditional pit-latrines was almost four times the amount of solid waste in pour-flush toilets. Solid wastes interfere with the pumping process of faecal sludge by blocking emptying horses, hence making the process unsightly and unhygienic because of spillages.

Plate 1: Solid wastes commonly found in toilets

Policy implications

- Results from this study imply that, the prevailing reliance on unsafe emptying practices can be attributable to the limitation in the design of toilet facilities. The current policy on sanitation improvement focuses on promoting adequate sanitation facilities i.e. toilet facilities that among other aspects, achieve emptying for further treatment of faecal sludge off-site (UNICEF & WHO, 2019)sanitation and hygiene targets within the Sustainable Development Goals (SDGs. The situation observed of toilet lacking important design features may slow down the journey towards universal adequate sanitation.
- The methods approved for emptying toilets are through the use of manual pumps and vacuum tracks because other emptying pits such as using manual hand tools are associated with difficulties in transporting faecal, hence leading to hapharzard disposal onsite. This study found that some of the toilets cannot be emptied using either hand pumps or vacuum track except manual tools. WHO guidelines on Sanitation and Health treats emptying sewage pits with manual tools as safe when performed with effective use of Personal Protective Equipment (PPE) while ensuring safe conveyance of the emptied faecal sludge off-site for further treatment(WHO, 2018). Hence, at the moment, toilets with faecal sludge that cannot be pumped out can benefit from emptying using manual tools as an interim measure while programmes for their phasing them out continue.

Recommendation

(a) Ministries of Health should update the Guidelines for the construction of toilets to emphasise on pit lining, use of strong slab cover, and provision of access points for emptying

Building on the urge to ensure adequate sanitation, guidelines on sanitation improvement should emphasise on the inclusion of toilet design features that facilitate emptying. These design features are fully lining the pit, using strong slabs and provision of access points for emptying the sewage pits. Promotion of full lining of toilet pits should be accompanied by community education on addressing possible reluctance as percolation of water shrinks the faecal sludge and

leaves the toilet usable for some time.

(b) Municipalities and Urban Water and Sanitation Authorities should conduct public awareness campaigns on limiting the disposal of solid waste in pits

Presence of solid waste in on-site sanitation facilities renders the facility's low likelihood of being hygienically emptied. Municipal Councils should, therefore, promote proper solid waste management and avoid throwing them into pits to facilitate future emptying.

(c) Ministries of Health and Water in collaboration with Municipal Councils and Urban Authorities should prepare a short-term programme for facilitating the emptying of pits that can only be emptied using manul hand tools and sustain their phasing out

Some of the toilets were already full to the brim and contained faecal sludge that could not be pumped out either hand pump or vacuum tankers. Since manual tools need to be employed with caution, a special programme can be developed to phase out toilets that cannot be pumped out as a way of emptying them.

Conclusion

Pit emptying remains a key step in urban sanitation improvement. However, toilet design features play a key role in facilitating emptying without risking public health and environmental pollution. As the globe looks forward towards achieving adequate sanitation for all, inclusion of features such as side-lining, use of strong slabs, inclusion of access points for emptying is key to the attainment of this goal. Overall, this process entails developing of guidelines for emphasising on inclusion of key aspects as well as sustaining awareness on the proper usage to limit solid wastes from entering toilets.

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Improving Menstrual Hygiene Management in Secondary Schools

By

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Background

The rapid increase in secondary school enrolment following the Secondary Education Development Programme (SEDP) intervention in 2004 aimed to enrol all those who had passed the primary education examinations to qualify for secondary school has placed a heavy burden on the existing infrastructure, particularly WASH facilities (SNV/Water Aid/UNICEF, 2011). As a result, the number of schools and students in Tanzania has increased tremendously in recent years, particularly in community-based schools (Mlozi et al., 2013). An increase in the number of students was not accompanied by an increase in sanitary facilities, including menstruation facilities. Failure to provide appropriate menstrual hygiene facilities at home or in school could prevent WASH services from being used as intended (Shoemaker, 2008). Adolescent females at schools demands adequate sanitary facilities for managing their menstrual wastes during 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 and 70% of the girls/women in Tanzania prefer to use disposable pads (SNV, 2011).

This policy aims to show the situation on menstrual hygiene is practised and how menstrual wastes are managed at the school between private and public schools, also the formulation and implementation of policies that promote the reproductive health and education rights of girl students by tackling problems associated with managing menstrual flow and improving access to appropriate menstrual waste disposal.

Key Messages

Girls prefer to use menstrual pads

Sanitary towels (pads) were described by almost all the girl students as their preferred method for managing menstruation. About 97.1% of the schoolgirls were found to use disposable sanitary pads as their only absorbent material during their last menstruation at schools and 2.9% used rags. During an FGD one girl hear said: "*Sometimes I used a rag because of lacking money to buy pads but wish to use menstrual pads because it easy to use*." This shows that use of pads is widespread to some extent among the schoolgirls in both private and public schools.

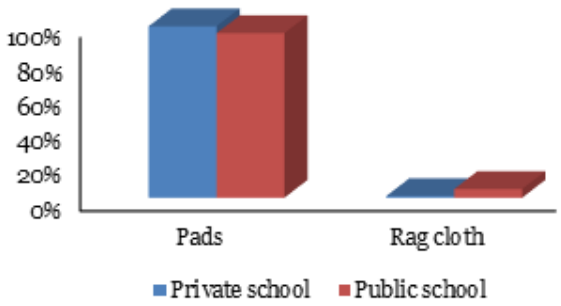

Figure 1: Menstrual material used

Inadequate collection and disposal of menstrual waste

From the study conducted and projection made it is expected that the daily collection rate of the disposable menstrual pads will be higher for private than public schools, as Figure 2 demonstrates. There is lack of or inadequate unsafe disposal for menstrual waste materials, with schoolgirls being forced to dispose them of in school latrines, which can lead to filling up of the latrines with solid wastes mostly done in public schools as Figure 3 illustrates. In future (5 years' time), the menstrual waste management challenges in schools are likely to go up even higher than presently if the safe menstrual waste collection and disposal facilities are not well-defined and considered.

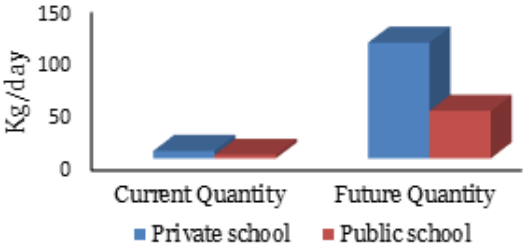

Figure 2: Quantity of menstrual waste collected

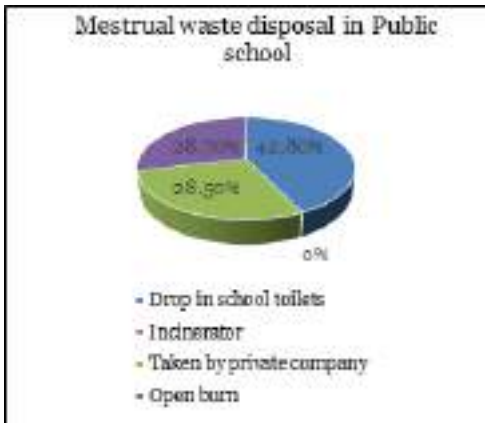

Figure 3: Menstrual waste disposal between private and public schools

Unsatisfactory/Poor of toilet conditions

Observations during the study conducted established that toilets were in a poor state for use. In other words, there was no privacy, water, hand-washing facilities, with no collection facilities as Plate 1 (below) illustrates; this shows that there is a need for a good design because some toilets are pit-latrines which tempt students to throw their menstrual waste into them:

Plate 1: Toilet condition

Recommendations

Provision of menstrual pads at low-cost

CBOs and NGOs should lobby the government for the reduction of the price of sanitary pads and other menstrual flow commodities to make them more affordable to schoolgirls. This could be done through subsidies extended to these essential commodities.

Management of menstrual disposal facilities

Municipalities should ensure that all the schools follow the MH waste management guidelines to ensure safe disposal.

Conclusion

As menstrual waste disposal poses a big challenge in the face of soaring numbers of female students in school, the generation of menstrual waste will inevitably increase. To improve MHM, the government should subsidise sanitary pads and other menstrual flow commodities to make them more affordable and accessible for schoolgirls. Municipalities should also ensure that all the schools followed MH waste management guidelines to ensure safe disposal.

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Promoting the Use of High-Rate Algal Ponds as Alternative Wastewater Treatment to Conventional Waste Stabilisation Ponds

By

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Introduction

The common wastewater treatment technology used in Dar es Salaam is Waste stabilisation ponds (WSPs). This treatment technology is fraught with many design and operational related problems. Although they are effective for domestic, municipal and industrial wastewater treatment (Butler *et al*., 2017), the effluents of many pond systems including that of the University of Dar es Salaam contain excessive concentration of nutrients (Mayo, 2020). These high levels of nutrients accelerate the growth of algae blooms on the surface of storage ponds, which sometimes affect the operation of the entire pond system primarily because this technology was not designed to optimise the recovery of resources from wastewater (Craggs *et al*., 2014).

Moreover, untreated or partially-treated effluent from conventional ponds also poses health risks to the public due to presence of numerous pathogens causing diseases such as cholera, diarrhoea, typhoid, dysentery and hepatitis (*Liu et al*., 2017). As such, there was a high-rate algal pond (HRAP) as this wastewater treatment technology designed for both wastewater treatment and resource recovery becomes an alternative for solving both wastewater treatment efficiency and resource recovery. After all, the nutrients embedded with microalgae can be harvested from the reclaimed wastewater. As such, the technology becomes an ideal option since it can help to solve problem of water scarcity and food security. Reclaimed wastewater can be used for irrigation, with the nutrients recovered from microalgae serving as a source of nutrients mostly protein for animal feeding notably poultry (Camacho, 2019).

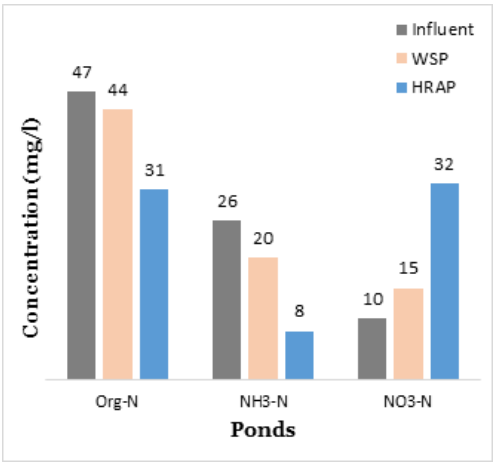
The study was conducted to compare the performance and behaviours of conventional ponds (WSPs) as well as high-rate algal ponds, which were locally built as pilot study at University of Dar es Salaam near the existing Wastewater stabilisation ponds. Conventional pond WSP) and experimental pond (HRAP) with similar dimensions of length and width 7 m (length) and 2 m (width) with differences in depth 1.5 m and 0.3 m respectively were assessed.

Figure 1. Existing situation of WSPs in Dar es Salaam A) Primary Facultative pond (UDSM) B) Buguruni primary facultative pond C) Mabibo primary facultative pond.

Key Messages

HRAP demonstrated good performance in wastewater treatment more than Waste Stabilisation Ponds

Figure 1 shows values of nutrients (nitrogen) and microbial parameters from raw wastewater influent to treated wastewater (WSP and HRAP). The results reveal that, HRAP can be adopted since all the parameters tested produced positive results by showing high treatment performance of HRAPs over the conventional ponds. Similarly, faecal coliforms have been reduced to 3 logs from 108 (raw wastewater) to 105 in HRAP.



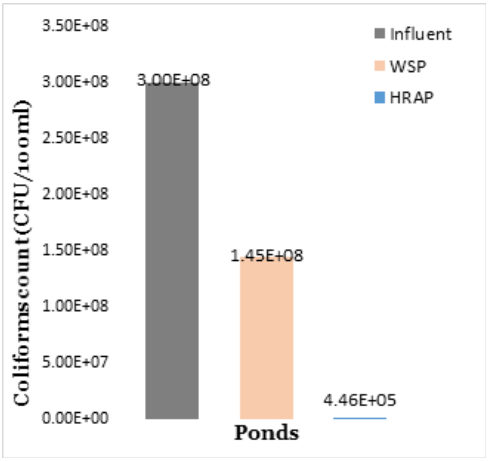


Figure 2. A) Nitrogen concentration in ponds system B) Comparison of faecal coliform counts in ponds.

HRAPs produce massive biomass of microalgae than WSPs

Figure 3. presents the results for biomass production (dry weight) whereby there is much production of biomass content in HRAP (503mg/l) as compared to (83mg/l) in conventional WSP. This implies that microalgae production in HRAP can be harvested for resource recovery.

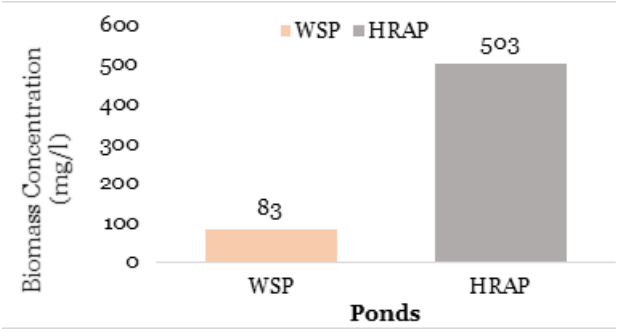


Figure 3. Variation in biomass concentration of microalgae in ponds

HRAPs microalgae have more nutrition values than WSP

Table 1 shows results from analysed biochemical components of microalgae. From the findings, all the chemical components were found to be higher in HRAP than in WSP with the highest amounts of protein. The difference in protein content between the two media was possibly due to the difference in nitrogen composition.

Table 1: Proximate composition of microalgae biomass cultivated in ponds (Nutrients composition)

Ponds	Nutrition Composition (%)			Energy
	Protein	Lipids	Carbohydrates	kJ/100 g
WSP	45.87±8.59	11.09±0.76	10.38±1.31	324.82±39.75
HRAP	67.78±7.46	14.08±0.48	13.74±1.23	452.91±42.14

Policy Implications

Study findings imply that there is a need to improve the conventional waste stabilisation ponds focusing on the design mechanism to allow for more treatment efficiency.

High-rate algal pond provides an opportunity for using end-products such as microalgae, which is vital for the recovery of dissolved nutrients that become incorporated into the algal biomass.

Policy Recommendations

a. The Ministry of Water should update the DCOM manual to include the use of HRAPs for the treatment of wastewater and resource recovery.

b. The national certification board (i.e. Tanzania Bureau of Standards [TBS]) should develop the guidelines and standards for safe use of harvested microalgae

Conclusion

As wastewater treatment poses an increasingly a big challenge amidst ever rising population growth, which inevitably increases food demand substantially in subsequent decades, there is a need to develop alternative and appropriate technologies aimed to meet demands for efficient wastewater treatment and for resource recovery, with the High-rate Algal Pond emerging as a sustainable alternative in this study.

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Upscaling the use Of Biodigester for Sustainable Treatment of Human Placenta in Health Care Facilities

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Background

Treating and disposing of biodegradable pathological waste is a critical problem for many healthcare facilities. Many countries have revised codes of practice and made recommendations for handling and disposing of medical wastes from hospitals. All categories of solid wastes generated by healthcare facilities need to be handled, transported, and disposed of in a controlled manner to safeguard public health and prevent environmental pollution (Senatore, 1994). In Tanzania, the main disposal methods for medical wastes in healthcare facilities comprised open pit burning, burying and incineration. These methods are associated with high operational cost, health, and environmental risks to the operator (Manyele and Anicetus, 2006). The special wastes include the placenta. Such wastes are treated as regulated medical wastes (RMW) (Davis, 2000; Hall, 1989). Although there are many ways of handling regulated medical wastes, incineration is the most common method applied worldwide, especially the on-site incineration (Park and Jeong, 2001; Hyland, 1993). Very few studies have been conducted on the proper management of medical wastes, placenta being inclusive (Bdour*et al.,* 2006). Mwananyamala referral hospital in Dar es Salaam installed pilot anaerobic biodigester as an alternative sustainable method for the management of placenta waste generated at the hospital.

Key massage

Operational cost for human placenta waste treatment using a digester is low.

The operational cost for running an incinerator for managing placenta waste before the use of the biodigester was higher than the operational cost of the biodigester, which also makes biogas used serve as a source of energy, as Figure 1 illustrates:

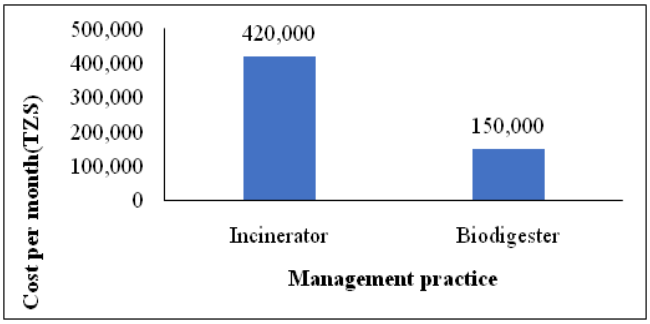

Figure1: Operational cost for managing placenta waste

There is enough biogas produced from placenta fed anaerobic digester

The quality parameters of biogas was analysed using the gas analyser model GIR5500. Methane (CH_4), as a pure combustible biogas, was composed of 83.2% whereas Carbon dioxide (CO_2), Hydrogen Sulphide (H_2S) and Oxygen were 14%, 2.8% and 0%, respectively (see Table 4.1). The results signify that biogas production occurs in a strict anaerobic environment necessary for such a process. The results also suggest gas purification to remove carbon dioxide and hydrogen sulphide. Since carbon dioxide is a fire-extinguisher when mixed with methane, it reduces the burning capacity of methane. Hydrogen sulphide should be removed from biogas because the gas is toxic, and when inhaled by user it can lead to health issues such as cancer and lung issues (Sasse,1988).

Table 1: Gases composition in a biogas reactor

S/N	Gas	Percentage (%)
1	Methane - CH_4	83.2
2	Carbon dioxide - CO_2	14
3	Hydrogen sulphide - H_2S	2.8
4	Oxygen - O_2	0

Biogas produced at Mwananyamala hospital is serves as an energy source for boiling water for use in the maternity ward, as Plate 1 illustrates:

Plate 1: Biogas stove for boiling water at Mwananyamala hospital

The biogas can be produced more by co-digestion

The laboratory scale reactors tests done by comparing the volume produced on placenta only and that mixed with FS. The co-digestion resulted into higher volume of biogas by 31.5% as compared to the placenta only.

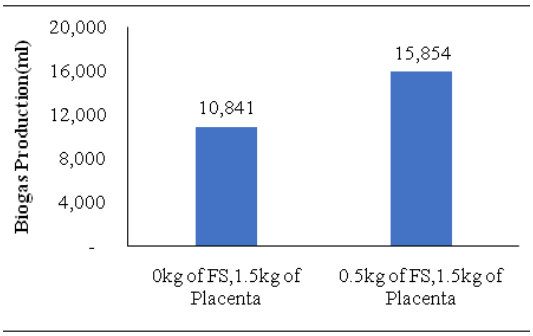

Figure2: Impact of seed in biogas production

Policy Implications

The research findings suggest that placenta waste management by the anaerobic digester is viable relative to the other methods due their health and environmental risks. The incineration of human placenta waste, which is the common method in urban areas, is linked to air pollution, economic losses and health hazards for people exposed to the facility (Bdour*et al.,* 2006; Park and Jeong, 2001; Senatore, 1994; Hyland, 1993).

Policy recommendation

Upscaling the use of Anaerobic digester for placenta waste management

Health facilities should adopt the use of Anaerobic digesters for the management of placenta wastes as an alternative to incinerators and other methods.

Review of design of biodigester

The manufacturers and producers of biodigesters should review the design to accommodate biogas purification. Also, producers need to introduce seeds, which may act as an activator to the feeding material (placenta) because doing so has produced favourable results in biogas production as compared to when only the placenta is involved.

Conclusion

The safe management of placenta waste in health facilities is an important practice. It requires the use of the proposed method—the Anaerobic digester. This method also results in biogas generation, which can also serve as an energy source in health facilities to reduce their inherent operational costs.

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