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Research article

Local scale water-food nexus: Use of borehole-garden permaculture to realise the full potential of rural water supplies in Malawi

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ABSTRACT

Local-scale opportunities to address challenges of the water–food nexus in the developing world need to be embraced. Borehole-garden permaculture is advocated as one such opportunity that involves the sustainable use of groundwater spilt at hand-pump operated borehole supplies that is otherwise wasted. Spilt water may also pose health risks when accumulating as a stagnant pond. Rural village community use of this grey-water in permaculture projects to irrigate borehole gardens is proposed to primarily provide economic benefit whereby garden-produce revenue helps fund borehole water-point maintenance. Water-supply sustainability, increased food/nutrition security, health protection from malaria, and business opportunity benefits may also arise. Our goal has been to develop an, experience-based, framework for delivery of sustainable borehole-garden permaculture and associated benefits. This is based upon data collection and permaculture implementation across the rural Chikwawa District of Malawi during 2009–17. We use, stakeholder interviews to identify issues influencing uptake, gathering of stagnant pond occurrence data to estimate amelioration opportunity, quantification of permaculture profitability to validate economic potential, and critical assessment of recent permaculture uptake to identify continuing problems. Permaculture was implemented at 123 sites representing 6% of District water points, rising to 26% local area coverage. Most implementations were at, or near, newly drilled community-supply boreholes; hence, amelioration of prevalent stagnant ponds elsewhere remains a concern. The envisaged benefits of permaculture were manifest and early data affirm projected garden profitability and spin-off benefits of water-point banking and community micro-loan access. However, a diversity of technical, economic, social and governance issues were found to influence uptake and performance. Example issues include greater need for improved bespoke garden design input, on-going project performance assessment, and coordinated involvement of multi-sector governmental-development bodies to underpin the integrated natural-resource management required. The developed framework aims to manage the identified issues and requires the concerted action of all stakeholders. Based on the probable ubiquity of underlying issues, the framework is expected to be generalizable to the wider developing world. However, this particular application of permaculture represents a fraction of its greater potential opportunity for rural communities that should be explored.

1. Introduction

Opportunities to address the challenges of the water–food nexus at the local-community scale should be proactively embraced. This is especially true in the rural developing world,

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particularly Sub-Saharan Africa (SSA) where water and food security concerns may abound within impoverished conditions. Malawi is a low-income country, amongst the least developed globally (UN CfDP, 2016). Most of its 17 million people reside in rural areas where a series of issues pervade that demographic. Water is central to survival and issues that stem from Malawi's water problems are many (Mulwafu et al., 2003). The sustained delivery of safe drinking water represents a major challenge. Agriculture, central to the economy, is critically dependent upon water, particularly rainfall that falls seldom outside of the wet season. Frequent drought and flood events ruin crops and impinge upon the national yield and cause food insecurity (ActionAid, 2006; Branca et al., 2016). Southern Malawi is particularly vulnerable to such events and possible climate-change exacerbation. Many small-scale farmers produce less food than they need to consume and may need to resort to buying food at the market, especially during the lean season (Ellis and Manda, 2012). Some may go hungry as prices of staple crops increase during that season.

Tens of thousands of boreholes, 'water points', exist across Malawi that provide drinking and domestic water supply to rural village communities (Pavelic et al., 2012). The vast majority have been installed under international aid programmes facilitated by NGOs (non-governmental organisations) in liaison with the Malawian government. Most boreholes are fitted with hand pumps allowing villagers to pump and collect their own water supply for drinking, washing and other domestic use. The collection process may, however, involve spillage of abstracted groundwater. This is not only a waste, but also constitutes a health hazard as spilt water frequently accumulates in stagnant ponds. These unfortunately provide mosquito breeding grounds leading to increased malaria risks (Ecological Society of America, 2011); Southern Malawi is a malaria-endemic area. Moreover, ponds may also serve as watering holes for animals and hence become a proximal disease hazard to the water point due to animal defecation nearby. A further consideration is that funds need to be generated to sustainably maintain a water point thereby freeing the community from aid support. Key concerns are hence to realise the full potential of abstracted groundwater and adjoining land resources, avoid water and land waste, minimise health risks, and deliver sustainable water supply alongside other benefits, notably increased food security and socioeconomic benefit. Our contention, actively progressed in Malawi since 2009, is that 'borehole-garden permaculture' may provide an elegant solution to these concerns and deliver a range of benefits to a participating local community.

Permaculture was founded in the 1970s as a system of agricultural and social design principles that synergistically and adaptively centres upon natural ecosystems (Holmgren, 2002). It encourages the best use of natural resources without waste and continues to be innovated upon globally (Akhtar et al., 2016; Birnbaum and Fox, 2014; Bradley, 2014; Greenblott and Nordin, 2012; Hemenwey, 2015; Mancebo and De la Fuente de Val, 2016; Vitari and David, 2017). Modern-day permaculture embraces: "*Consciously designed landscapes which mimic the patterns and relationships found in nature, while yielding an abundance of food, fibre and energy for provision of local needs. People, their buildings and the ways in which they organise themselves are central to permaculture. Thus the permaculture vision of permanent or sustainable agriculture has evolved to one of permanent or sustainable culture.*" (Holmgren Design, 2017). Malawi is no stranger to permaculture. Pioneering work by the Nordin family (with the US Peace Corps) in the 1990s was triggered by the need for HIV prevention and care. They critically recognised that permaculture could provide a sustainable solution to the malnutrition, food insecurity, and poverty issues that undermined achievement of their health-related goal (Nordin and Nordin, 2014). The value of permaculture to Malawi's local-scale development of food and nutrition security is increasingly being recognised (Vidal, 2016).

Our concept of, village community, borehole-garden permaculture involves the collection of abstracted groundwater spilt in the vicinity of hand-pumps. This collected 'grey water' is channelled into a fenced-off permaculture garden area where it is distributed, ideally passively, throughout the cropped garden area. Year-round water availability allows for a perennial food source opportunity, including the lean season. Garden produce is sold to raise income to help fund water-point maintenance, lower tariffs and possibly fund other enterprise. Stagnant ponds and associated health risks are thereby removed. The approach constitutes a local-scale application of integrated water resources management (IWRM) and realises sustainable use of both water and land natural resources (Hoko and Hertle, 2006). It engenders a 'grassroots', community participative, approach (Kishindo, 2003; Hussein, 2003; Mulwafu and Msosa, 2005), albeit recognising the community-based groundwater management paradigm pervasive across rural SSA is not a panacea (Van Den Broek and Brown, 2015).

The primary novelty of such a borehole-garden permaculture approach, at least for Malawi at the inception of our work, and it would seem internationally, is the proactive utilisation of borehole wastewater together with delivery of circular-economy benefit. This emphasis contrasts with handpump-borehole community gardens typically found in the literature where there is purposeful abstraction of groundwater for irrigation use, so-called 'small or micro-irrigation' schemes. Such schemes do, however, tend to realise a range of benefit type not dissimilar to those illustrated by borehole-garden permaculture herein. The pioneering work in Zimbabwe of Lovell et al. (1996) and Waughray et al. (1998) is particularly illustrative of the significant community benefit that is possible through a proactive small-irrigation scheme involving a reasonably large-area community-garden approach.

Our research focuses upon the Chikwawa District within Southern Malawi where water, food and health-security issues abound. Our overarching goal is to develop a strategic framework for effective borehole-garden permaculture implementation and management. Impetus for this ambition is provided by our early observations of relatively low uptake of permaculture. Moreover, when implemented, some gardens were failing and becoming abandoned, even returning to stagnant pond conditions. Our multifaceted approach to this goal is built on underpinning activity conducted since 2009 (Stark, 2011) and comprises:

- Stakeholder interviews in 2012–13 (Halcrow, 2013) to identify confounding technical, economic, social and governance issues that impinge upon permaculture performance (supplemented by interview data from our companion IWRM study of Schmalfuss (2014));
- Surveying of borehole stagnant pond occurrence across Chikwawa to assess the opportunity for targeted reduction of waste water and health risks;
- Scoping calculations to establish the economic value of permaculture;
- Critical assessment of recent permaculture uptake to identify the current status and continuing issues; involving, evaluation of promotion activity, recent (2015–16) mapping of permaculture occurrence, and very recent (2017) informal review of some projects.

The developed framework is hence research, multi-stakeholder, and implementation-experience informed. It is based upon a collaborative university, NGO, national/local governmental body and village community participation effort. It also recognises that a framework should ideally be 'generalizable' to the wider