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Social seed networks: Identifying central farmers for equitable seed access

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ABSTRACT

Community-based agrobiodiversity management projects have been at the forefront of integrating informal seed systems into food security initiatives. These projects co-create open-pollinated crops and reintroduce lost varieties. A prevailing critique regarding these projects regards unequal distribution of seed to communities — quality seed, when introduced, does not reach target populations. The purpose of this study is to identify key farmers who can distribute open-pollinated seed through their existing, diverse social channels and evaluate if this method enables vulnerable populations to access improved varieties. Data was collected and combined from two subsistence-based communities in Northern Ghana. This study combines social seed network analysis and regression to determine centrally connected farmers over their project areas. To understand which types of farmers have the most equitable and efficient seed distribution networks, this study uses harmonic closeness centrality as a dependent variable in a set of ordinary least squares regressions. Results suggest that harmonic closeness centrality can best be estimated per study community, but results were not constant after combining communities. Two warnings emerge from this analysis: i) central farmers can leverage their control on resources to maintain their network position, which may promote unequal seed dissemination, and ii) seemingly analogous networks may be difficult to compare when combined due to a scale mismatch between analysis and intended analysis utility (i.e. seed dissemination). These findings validate the utility of social network analysis in unfolding the socioecological complexity of informal seed systems; yet offer warning on using network parameters for equitable (re)introduction of open-pollinated varieties.

1. Introduction

Global food insecurity has never been as prevalent as today. About one-sixth of the developing world's population lacks access to the sufficient foods needed to maintain healthy, productive lifestyles (FAO, 2012). Notably, Sub-Saharan Africa has among the most extreme percentages of food-insecure people, remaining around 33 to 35% since 1970 (Mwaniki, 2006). Crop biodiversity has decreased 75% worldwide since the turn of the 20th century (FAO, 2012) due to decreases in landholdings, intensification of farming practices, and introduction of closed-pollinated modern varieties, which cannot be saved each year (Bellon et al., 2011; Pautasso et al., 2012); this decline is a key reason for rural food insecurity in the Global South (Pautasso et al., 2012). Brush (1991) defines 'agrobiodiversity' as crop biodiversity that acts as the cohesive social and ecological life-support system — it sustainably supplies food access through promoting healthy topsoil, clean water, air, and carbon sinks.

Traditionally, agrobiodiversity is maintained by informal seed systems, in which subsistence-based farmers engage in social contracts with one another, exchanging locally adapted seeds to ensure that they have enough to plant each season (Almekinders and Louwaars, 1999; McGuire, 2007; Louwaars and De Boef, 2012). Importantly, these farmer varieties are open-pollinated and can be saved for repeated use in upcoming seasons, dramatically reducing overall input costs for resource-poor farmers (Sallah et al., 2007; Tripp and Mensah-Bonsu, 2013). Social relationships, such as kinship alliances, facilitate seed and information exchanges necessary for continual and equal seed access when there are insufficient yields (Almekinders and Elings, 2001; Badstue et al., 2006; Abay et al., 2011). However, as subsistence farmers transition from a barter system to a cash-based economy the magnitude of market-oriented agriculture development of hybrid varieties becomes a leading cause for the decline of traditional varieties (Cromwell and van Oosterhout, 2000; Bellon et al., 2011; Pautasso et al., 2012). Resource-poor farmers with minimal access to technical information and quality inputs are especially vulnerable to make this transition (Tripp, 2001).

Throughout Sub-Saharan Africa, community-based agrobiodiversity management projects have been at the forefront of recent development solutions that integrate and strengthen informal seed systems into food security initiatives (De Boef et al., 2013). Many of these projects seek to work with farmers, extension agents, and plant breeders to resupply communities with lost traditional varieties and/or to co-create open-pollinated crop varieties that utilize local and modern techniques — a

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method known as participatory plant breeding or PPB. Supplying open-pollinated seeds is essential for farmers to maintain locally adapted varieties that can better adapt to climatic shocks, require fewer inputs, and can be saved year-to-year (Almekinders and Elings, 2001). However, disseminating quality PPB seed to the most resource-poor farmers has been a recognized challenge for many of these initiatives (Ceccarelli and Grando, 2007; Dorward et al., 2007). Introduced varieties often have minimal adoption rates because of low farmer-to-farmer exchange (Dogbe et al., 2002; Ceccarelli and Grando, 2007). Dorward et al. (2007) reflected that the farmers involved in their project were only connected to a few other farmers and hence held limited diffusion capabilities; the researchers failed to identify key farmers that could efficiently distribute the improved, open-pollinated seed. If these research teams had a better understanding of how seed flowed throughout the informal seed system and which farmers were optimal seed brokers, the project could have diffused the varieties to a wider breadth of community members.

My study outlines an approach for projects disseminating open-pollinated seed to reach as many farmers as possible with the smallest amount of resources. Community-based agrobiodiversity management projects' ability to identify key, well-connected farmers will positively affect their ability to distribute improved seed to more diverse groups of farmers (Abay et al., 2011). Specifically, my study examines whom central farmers in their seed exchange network, and if leveraging these farmers' social relationships to distribute seed will reach the poorest households and female farmers who are often the aim of community-based agrobiodiversity management projects. Using social 'seed' network analysis (Gupta and Chandak, 2010; Abay et al., 2011; Pautasso et al., 2012) I first model which types of farmers are situated at the center of their seed exchange networks, then discuss if these central farmers are given improved seed would they enable or disenable equitable seed access to their community.

2. Theoretical background

2.1. Social networks and informal seed systems

Past studies have used ethnographic approaches, surveys, and genetic analysis to examine how informal seed exchange affects both the evolution of traditional varieties and the social systems supporting their continual adaptation (Vom Brocke et al., 2003; Pandey et al., 2011; Pautasso et al., 2012). These methods have been useful in providing policy frameworks to protect traditional species diversity and in informing strategies that strengthen human dimensions of informal seed systems in community-based agrobiodiversity management projects. These studies have described rich farmer-to-farmer trade systems, where kinship alliances, gender relations, market fluctuations, development policies, and climatic factors present dynamic indicators describing when farmers seek seed and who they solicit (Brush, 1991; Almekinders and Elings, 2001; Pautasso et al., 2012).

However, the application of social network information to seed sector development may lead to more equitable farmer access (Pautasso et al., 2012). Only a few studies have used social seed network analysis to measure how seed flows through these systems and to identify key farmers as entry points (Subedi et al., 2003; Abay et al., 2011). For instance, Subedi et al. (2003) observed how 25 different rice varieties were traded across several villages in mountainous regions of Nepal. They found that relative trading distance mattered more than kinship. Their findings revealed further nuances in the impact geographical distance has on informal seed exchange; farmers living close to one another were able to exchange information about the seeds as well as provide better-suited varieties for their shared agroecological niche. While the distances between trading partners have been observed and cross-verified in non-network studies (Hodgkin et al., 2007; Stromberg et al., 2010; Chambers and Brush, 2010; Bellon et al., 2011), the ability to visually map and quantify seed flows further described how these informal seed systems operated.

My study adds to this body of literature by applying social network information to seed sector development. My goal is to examine if improved seed distribution will lead to more equitable farmer access by identifying central farmers with high diffusive capabilities.

2.2. Centrality measures

One of the key ways community-based agrobiodiversity development projects can use social seed network analysis is by identifying the most central farmers to distribute introduced, open-pollinated crop seed in their communities. Centrality measures the degree in which an individual is connected to others in his/her network through relationships, experiences, or exchanges of goods and information (Borgatti et al., 2013); farmers with high levels of centrality are able to distribute seed to more farmers in their network than farmers with low levels of centrality. However, a farmer may be directly connected to a high amount of other farmers, but if in an isolated clique, where their connections are not connected to the broader seed exchange network, their ability to diffuse seed past their subgroup is limited. Abay et al. (2011) identified three centrality measures to detect key farmers who disseminate open-pollinated seed and pertinent information: degree, betweenness, and harmonic closeness. Each centrality measure has specific applications to crop seed dissemination that needs careful consideration before a project identifies one for their implementation.

The first centrality measure, 'degree centrality,' relates to the number of individuals with whom a single farmer directly exchanges crop seed. For instance, if a farmer trades seed with four other farmers, the degree centrality score is four (Abay et al., 2011). Since this measure cannot estimate the farmers' subsequent trading partners, this is not the best measure for open-pollinated seed that will be disseminated over multiple seasons of seed saving and exchange. This measure does not allow analysis on if socially vulnerable groups have indirect access to receiving seed from central farmers. For example, female farmers may not be connected to male farmer seed exchange networks, yet they have been found as critical to crop variety maintenance (Gill et al., 2013). If indirect ties are not taken into account, key groups may not gain access to introduced varieties.

The second centrality measure, 'betweenness centrality,' is a global measure that accounts for all the farmers in a given network by measuring nodes situated on the shortest path between all network members. This measure accounts for both direct and indirect ties (Borgatti et al., 2013). Individuals with high betweenness scores are positioned to control or influence the flow of seed exchange and to link groups of farmers that are not otherwise connected (Abay et al., 2011). This measure is useful when trying to bridge subpopulations in an informal seed system. However, depending upon which parts of the network the individual is bridging, central farmers may only give seed to certain subgroups of individuals that are not in turn connected to additional subgroups. A farmer's ability to bridge his or her network has implications for informal seed exchange because one prevalent issue in improved seed distribution has been uneven dispersal, where vulnerable populations have neither sustained nor immediate access to introduced seed (Gupta and Chandak, 2010). Furthermore, when there is a high amount of social proximity between actors there is often a mixture of opportunism and limited economic rationale (Boschma, 2005). Hence, the subgroups a farmer interacts with are not always purposeful, but often implicitly based on cultural norms and geographic proximity that allow for trust between partners to be established over longevity of interactions. A key principle of network interactions, homophily, suggests that individuals who find themselves in the same proximity as others commonly share characteristics, such as gender, wealth, or age (McPherson et al., 2001). If a farmer with high betweenness centrality is bridging subgroups, it is most likely based on with whom they are able to interact. Thus, both degree centrality and betweenness measures fail to represent equitable seed distribution to all farmers in the network because