Journal of Rural Studies xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Journal of Rural Studies

journal homepage: www.elsevier.com/locate/jrurstud

Determinants of crop diversification in rice-dominated Sri Lankan agricultural systems

Emily K. Burchfield[a,*], Arielle Tozier de la Poterie[b]

[a] Department of Environment and Society, Quinney College of Natural Resources, Utah State University, USA
[b] Center for Science and Technology Policy Research, University of Colorado, Boulder, USA

ARTICLE INFO

Keywords:
Diversification
Sri Lanka
Rice

ABSTRACT

Climate-driven changes in water availability in tropical agricultural systems will force many farmers to significantly alter their cultivation practices. In agricultural systems dominated by water-intensive rice cultivation, farmers may need to diversify away from rice to crops that perform better in the new climate. We combine data from interviews and household surveys with Sri Lankan farmers to identify the factors that influence farmers' decisions to diversify away from rice monoculture. Results indicate that many farmers cannot diversify because of the characteristics of their fields, including elevation, soil quality, irrigation infrastructure, and relative position within an irrigation system. As a result, policies that assume all farmers are able to engage in diversification are unlikely to have the desired impact. Of the farmers whose fields can support diversification, poor market access, market instability, limited government support, and relatively high input costs reduce diversification rates. In addition to creating a supportive institutional environment for the cultivation of other field crops, leveraging existing water management institutions to identify and support farmers with fields suitable to diversification could decrease agricultural water demands and increase water access for farmers unable to engage in diversification.

1. Introduction

Future changes in water availability will disrupt global agriculture, threatening agricultural production and increasing the risk of crop failure (Field et al., 2014; Lobell et al., 2011). These disruptions will be particularly severe in tropical agricultural systems, many of which are dominated by irrigated rice cultivation (Challinor et al., 2014; Kim et al., 2013; Rosenzweig et al., 2014; Wheeler and von Braun, 2013). Changes in the timing and duration of seasonal precipitation across South Asia will likely decrease water availability for rice cultivation (Kim et al., 2013; Lobell et al., 2011; Soora et al., 2013; Tao et al., 2008). Continued rice cultivation may be possible through the use of drought-tolerant cultivars, changes in the timing of planting and harvest, or the use of water-saving technologies (Wassmann et al., 2009); however, in severely water-stressed regions, many farmers will be forced to cultivate crops that require less water and perform better in the new climate (Challinor et al., 2014).

As in many South Asian nations, rice is a central part of the Sri Lankan diet and economy. Rice is a staple of the Sri Lankan diet, with an annual per capita consumption of 100 kg, 40 kg more than the global average (Gamawelagedara et al., 2011). Over thirty percent of agricultural land is cultivated with rice, the majority of which is located in the northern dry zone of the island (Department of Census and Statistics, 2017). Dry zone farmers receive agricultural water from a massive network of centrally managed reservoirs, hydropower plants, and over 10,000 km of canals that store and deliver water from the wetter southern region of the island (Manthrithilake and Liyanagama, 2012). Today, these irrigation systems contribute significantly to the Sri Lankan economy, producing over 800,000 metric tons of paddy annually and generating enough hydropower to meet 40% of Sri Lanka's energy demand (Manthrithilake and Liyanagama, 2012). Traditionally, this infrastructure allowed dry zone farmers to cultivate rice during both the wet and dry seasons; however, in recent years, recurrent droughts have significantly reduced dry season rice cultivation (Burchfield and Gilligan, 2016). A recent 2014 drought affected the livelihoods of over one million Sri Lankans; 58% of the country had completely insufficient water to cultivate during the 2014 dry season (World Food Program, 2014). Scientists predict that the prevalence of dry season drought will increase in the future, which could have devastating impacts on the livelihoods of farmers who depend on the regular and predictable supply of irrigation water to cultivate rice (De Silva, Weatherhead, Knox and Rodriguez-Diaz, 2007). These changes

* Corresponding author.
E-mail address: emily.burchfield@usu.edu (E.K. Burchfield).

https://doi.org/10.1016/j.jrurstud.2018.05.010
Received 10 November 2017; Received in revised form 2 May 2018; Accepted 21 May 2018

will also exacerbate competition for water between agricultural, domestic, and energy sectors on the island (Davis et al., 2016; Perrone and Hornberger, 2016).

A number of adaptive practices could mitigate the impacts of changing climate on rice-dominated agricultural systems including the use of short-duration rice seeds, pest-resistant crop varieties, and alternative rice cultivation practices such as the system of rice intensification (SRI) or alternate wetting and drying. Our research team set out to identify the practices in which farmers are most interested and to identify barriers and opportunities for their promotion in the dry zone. The most common adaptive measure we encountered was diversification *away* from paddy to less water intensive other field crops (OFCs). This interest in diversification is echoed in national policy initiatives. The National Climate Change Adaptation Strategy emphasizes diversification *away* from rice towards less water-intensive OFCs as an important means of mitigating projected changes in agricultural water availability and of increasing agricultural self-sufficiency (Imbulana et al., 2006). The *Mahinda Chintana*, a government document outlining the nation's "vision for the future" states that the government should give "*high priority for further expansion of crops which can be grown locally such as onion, chili, cowpea, maize, green gram, finger millet, and other subsidiary food crops in order to achieve self-sufficiency in other field crops*" (Government of Sri Lanka, 2010). The government has provided funding for research and extension aimed at promoting OFC cultivation and has launched an "Accelerated Other Field Crop Production Programme" with the objectives of increasing agricultural production, meeting local demand for OFCs, and increasing domestic food security. Our research team's conversations with Sri Lankan policy makers and observations of seasonal water allocation meetings confirmed that Sri Lankan water management officials and many farmers see crop diversification as a means of addressing water shortages; however, despite these efforts and interest, OFC cultivation rates remain low (Chandrasiri and Baminiarachchi, 2015). Over the past ten years, the cultivated extents of the most popular OFCs like maize, onions, chilies, and manioc have rarely passed 15,000 ha, while the average cultivated extent of rice has been over 575,000 ha (Department of Census and Statistics, 2017). In what follows, we review known barriers to crop diversification that could explain low adoption rates for this potentially adaptive agricultural practice. We then integrate survey and interview data to identify specific constraints faced by Sri Lankan farmers when deciding to diversity away from rice cultivation.

1.1. Crop diversification

Diverse agricultural systems have a number of advantages for farmers and the environment. Agricultural diversity has positive impacts on the functioning of ecosystems, which in turn provide important services for agriculture. These include mitigation of agricultural losses to pests and wildlife (Bommarco et al., 2013; Chaplin-Kramer, O'Rourke, Blitzer and Kremen, 2011; Gardiner et al., 2009), increased soil health (McDaniel et al., 2014; Tiemann et al., 2015), and biodiversity (Schulte et al., 2017; Tscharntke et al., 2005). Research also suggests that diverse agricultural systems show increased resilience to changes in climate (Altieri, 1999; Makate et al., 2016; McCord et al., 2015; Smit and Skinner, 2002; Smit and Wandel, 2006) and reduce climate-related risk for farmers (Birthal et al., 2015; Bradshaw et al., 2004; Gaudin et al., 2015; Lin, 2011; McCord et al., 2015). Crop diversification can increase absolute yields and yield stability for a number of crops and thereby increase household income (Abson et al., 2013; Barrett et al., 2001; Bigsten and Tengstam, 2011; Dalsgaard and Oficial, 1997; Demissie and Legesse, 2013; Makate et al., 2016; Mhango et al., 2013; Njeru, 2016; Smith et al., 2008). Crop diversification, if coupled with increased market access to domestically cultivated crops, could increase the nutritional diversity of Sri Lankan households, particularly the expansion of pulses (gram, cowpea, soybeans, and groundnuts) to help meet protein requirements (Kerr et al., 2007; Makate et al., 2016; Nyantakyi-Frimpong, 2017; Sibhatu et al., 2015).

Research conducted in smallholder systems around the world identifies a number of factors that limit farmer access to crop diversification. We anticipate that many of these factors will also affect farmers in Sri Lanka. Switching to a new crop often requires hefty start-up costs and capital investments that can be prohibitively expensive for many smallholder farmers (Barrett et al., 2001; Barrett et al., 2001; Loison, 2015; Smit and Skinner, 2002). The switch also requires developing the experience and knowledge necessary to successfully cultivate the new crop (Makate et al., 2016). Seed availability and quality may be poor as new crops are introduced into the market and local infrastructures and markets to facilitate the processing and purchase of these crops may be underdeveloped (Joshi et al., 2006). Farmers may be unable to diversify because of competition with cheaper, imported version of the crop (Jayawardane and Weerasena, 2001). In the case of diversification away from rice cultivation, many other field crops require more labor and inputs to cultivate than rice (Dalsgaard and Oficial, 1997; Joshi et al., 2006). Another important consideration is the unsuitability of local environmental conditions or of a farmer's field may prevent diversification (McCord et al., 2015). Fields with inappropriate soil type, draining configurations, or irrigation infrastructure may be unsuitable for cultivation of specific crops. In addition, farmers who do not own their land are often subject to the cultivation preferences of the land owner (Burchfield and Gilligan, 2016; Dalsgaard and Oficial, 1997).

In Sri Lanka, there is a strong cultural attachment to rice cultivation. One report referred to crop diversification as a form of "cultural eviction" stating "*paddy cultivation … is an important aspect of the cultural ethos of the nation … from the first step of paddy preparation until the final stage of the harvesting process of paddy, various types of cultural practices and rites and rituals are carried out by the peasants. Substitution of paddy cultivation by any other crops may [disrupt] these cultural norms*" (Dharmasiri, 2008, p. 67). This cultural attachment to rice coupled with government subsidies supporting rice cultivation discourages many farmers from cultivating OFCs. Past experience suggests that similar institutional support for OFC cultivation could increase cultivation rates of OFCs and, potentially, profits for farmers. Prior to liberalization of the Sri Lankan economy, protective policies boosted local OFC prices and encouraged domestic production of OFCs (Imbulana et al., 2006). During this period, some regions of the dry zone reported OFC cultivation rates as high as 60 percent. Following liberalization, unfavorable trade prices pushed the government to establish minimum prices on paddy, which pushed farmers back into rice cultivation (Dharmasiri, 2008). Today, farmers associate OFCs with volatile markets, limited input access, and labor-intensive cultivation practices. However, research suggests that farmers who adopt OFCs have higher yields and seasonal profits than farmers cultivating rice (Chandrasiri and Baminiarachchi, 2015). OFC cultivation could potentially increase profits for dry zone farmers and reduce agricultural water demands in the region.

Our objective is to understand the specific physical, socio-cultural, economic, and institutional barriers faced by Sri Lankan rice farmers when considering diversification. While we anticipate that some constraints, such as field unsuitability, will be difficult to change, by promoting diversification in fields where farmers *are able* to diversify, water managers can ensure water deliveries to farmers who are limited in their cultivation options. By understanding and identifying these barriers, we can also directly inform government programs geared towards promoting diversification and increase the potential impacts of diversification on farmer livelihoods. We first explore these constraints using in-depth farmer interviews in one agricultural community. We then analyze household survey data to assess whether the constraints are relevant *across* dry zone households and agricultural communities.