SANDEE

Working Paper No. 116–17

Conservation of Genetic Resources of Crops: Farmer Preferences for Banana Diversity in Sri Lanka

Wasantha Athukorala

Muditha Karunarathna

ECONOMICS & THE ENVIRONMENT

South Asian Network for Development and Environmental Economics (SANDEE) PO Box 8975,
EPC 1056, Kathmandu, Nepal.
Tel: 977-1-5003222 Fax: 977-1-5003299

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Keywords
Banana
Diversity
Farmer preferences
Conservation
Sri Lanka

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Wasantha Athukorala

Department of Economics and Statistics
University of Peradeniya, Sri Lanka

Muditha Karunarathna

Department of Economics and Statistics
University of Peradeniya, Sri Lanka

February 2017

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SANDEE is financially supported by the International Development Research Center (IDRC), The Swedish International Development Cooperation Agency (SIDA), the World Bank and the Norwegian Agency for Development Cooperation (NORAD). The opinions expressed in this paper are the author's and do not necessarily represent those of SANDEE's donors.

This Working Paper series of electronic preprints based on research funded by SANDEE and supported with technical assistance from network members, SANDEE staff and advisors.

Faculty Advisor
Jeffrey Vincent

English Editor
Carmen Wickramagamage

Staff Advisor
Mani Nepal

Comments should be sent to
Wasantha Athukorala
Email: wathukorala@yahoo.com

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Abstract

This study investigates farmer preferences for banana diversity in Sri Lanka. First, we investigate farmers' attitudes towards banana cultivation in the country. Secondly, we estimate diversity selection models to identify the important factors that contribute to the conservation of banana diversity. The analysis uses survey data covering 450 banana growers in three different districts representing different climatic zones in the country. It employs the Poisson model and OLS for the Shannon Diversity Index to determine the key household, market and other characteristics that are important for the conservation of banana diversity. The study indicates that maintaining on-farm diversity is receiving increased attention from farmers as a strategy for mitigating production risk and protecting food security in the rural areas of Sri Lanka. The results of the study show that family size, education, experience, method of marketing, and attitude of farmers are the major determinants of banana diversity maintenance on farms. The study recommends a subsidy to farmers to cultivate traditional varieties for the purpose of maintaining farm diversity since farmers are attracted to new varieties for their productivity.

Keywords

Banana, Diversity, Farmer preferences, Conservation, Sri Lanka.

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1. Introduction

The banana is the most widely cultivated and consumed fruit in Sri Lanka. It is also an attractive perennial fruit crop for farmers due to its high economic gains throughout the year. Currently, nearly 60,000 hectares of land are under banana cultivation in Sri Lanka, which makes up roughly 54 percent of the total land under fruit cultivation, making it the fruit taking up most of the land under fruit cultivation. However, in Sri Lanka, it is primarily grown on small subsistence farms with plots less than 0.25 ha. According to statistics, annual banana production is around 780,000 metric tones while the average yield is 13 Mt/ha (Department of Census and Statistics, 2014). In addition to being a major staple food for farmers, banana is an important source of income, with excess production sold in local markets.

In Sri Lanka, 29 banana cultivars including two wild species have been reported (Department of Agriculture, 2012). While five of these species can be categorized as cooking bananas, the other varieties, excepting two wild species, are consumed raw. Given the low level of productivity of local varieties, the Government of Sri Lanka has attempted, since the year 2000, to introduce new banana cultivars including genetically modified (GM) and high-yielding varieties. However, in view of the threat that may affect the banana cultivation practices in the country, several environmental organisations have called for a 'no genetically modified or high yielding banana' campaign as they believe these practices will eventually destroy all the indigenous varieties of the island. Therefore, government's attempt to introduce GM and high yielding varieties was not successful among farmers[1] .

Another reason why farmers maybe reluctant to accept new varieties is the possible risk of eradication that their introduction pose to traditional varieties (Brush *et al*. 1992; Chavas and Holt,1996; Smale *et al*. 2002; Asrat *et al*. 2009).Farmers believe that due to new varieties various social, agronomic and plant disease may result in eroding the ability of farmers to cultivate traditional varieties in their farms.

Urbanization and commercialization are among the principal factors that lead to specialisation in a fewer number of varieties among farmers instead of maintaining diversity even in the case of a single crop (Smale *et al*. 1998; Salvatore et al. 2010). However, the diversity offered by the traditional banana varieties carry an array of ecological and socio-economic benefits including improved soil fertility and health benefits to consumers (Sirisena and Senanayake, 1997). But the commercial value of these varieties can be a relatively small component of their total use value in agriculture (Karunarathna, 2012) as market prices are not the best gauge of all such values. In general, variety choice for a farmer is determined by the trade-off between risk and expected return. The highest expected return for a farmer is expected by devoting the entire farm to a single variety. However, cultivating single variety may increase the risk as it is safer to grow more than one varieties (including less profitable varieties) in case the variety with the highest expected profit fails for any reason. From the perspective of social welfare, if farmers stop growing more varieties in their farms, it may be lost from the gene pool, and possible future benefits from being able to re-introduce some of the properties of those varieties can be lost. Thus, farmers that grow less profitable varieties are conferring a positive externality on society. This is why diversity on farms has social value beyond any private value though farmers have no incentives to include those non-marketed values in their decision making process.

[1] GM varieties are not cultivated in Sri Lanka. However, few high yielding varieties are cultivated by several agro-companies and those are not popular among the ordinary farmers.

Consequently, investments in conservation may not occur optimally, which is one reason why farmers' decisions and activities are gradually leading to a reduction in banana diversity in the country(Department of Census and Statistics, 2012).Among other possible reasons why farmers may select high-yielding verities are that (a)most benefits of conserving banana diversity are long-term (and inter-generational); their actual values are not traded in the market and (b) low-income farmers with lower levels of education may not have adequate knowledge regarding the total benefits of conserving crop diversity. Additionally, both sales promotion activities done by agro-chemical farms and credit facilities provided by the government/NGOs promote the cultivation of modern crop varieties using high levels of pesticides and chemical fertilisers[2]. These types of economic incentives often encourage the degradation of species diversity and discourage conservation among farmers (Van Dusen, 2000; Van Dusen *et al*. 2005).

Di Falco and Perrings (2003) have identified common issues faced by low-income farmers such as high discount rates, market imperfections, adverse government policies, and insecure property rights. They indicate that as long as policy makers underestimate the total benefits of conserving crop species diversity there will be simplified and less resilient agro-ecosystems, the number of services provided by which in the long run would be less. From this perspective, the main challenge facing researchers and policy analysts is understanding the factors causing an erosion in crop species diversity. Designing a mechanism that would provide farmers in developing countries with the economic incentives needed to adopt more sustainable land use and management practices with environmentally rich farming systems is therefore essential. Our paper contributes to that effort through its focus on factors affecting and ways to conserve banana species diversity among farmers in Sri Lanka.

Our study attempts to identify the determinants of banana diversity in Sri Lanka. It also explores farmers' attitudes towards banana cultivation practices including both GM and high-yielding varieties in the country. We use the Poisson Regression(PR) model and OLS model to analyse the data. The findings suggest that farms, households, markets and other characteristics have a great impact on variation in crop diversity levels across banana farms in Sri Lanka. Of especial importance with regard to banana diversity in our study area are variables such as family size, education, experience, land size, information availability, satisfaction with banana prices, distance to the market, and the availability of direct markets. The results of our study indicate that a majority of farmers believe that there are direct monetary gains to be made from having several varieties of banana on their farms. The findings also reveal that a majority of the farmers do not entertain any negative attitudes towards GM or high-yielding varieties. Thus, policy makers can use the findings of our study to develop appropriate incentives to protect banana diversity at farm level which will generate regional as well as global benefits in the future while also helping to reduce erosion in crop species diversity that is increasingly posing a major impediment to agricultural growth and sustainable development in Sri Lanka.

2. Theoretical Background

In order to estimate farmer preference for banana variety selection, we use a basic model developed by Singh *et al*. (1986), Taylor and Adelman (2003) and Van Dusen and Taylor (2005) according to which the utility a household derives from consumption of various goods and services depends on the preferences of its members. Preferences are in turn shaped by the characteristics of the household such as the age and education of its members and household wealth (Birol, 2004). Choices among goods are constrained by the full income of the household, the total time (T) allocated to farm production (F) and leisure (C_l), and a fixed production technology represented by $G(.)$. Suppose a farm household maximizes utility over consumption of market purchased goods (C_m), leisure (C_l), and owned farm outputs (C_f). The utility is maximized subject to budget, time and production technology constraints. Accordingly, household utility is influenced by a vector of household characteristics δ_h (Van Dusen and Taylor, 2005).

The prices of all market purchased goods (pm), farm inputs (px) and wages (w) are assumed to be exogenous (Karunarathna, 2012). Thus, it is possible to write the household utility maximization with relevant constraints as follows:

[2] Such a system can increase short-term yields while destroying the resilience of agro-ecosystems in the long-term.

Maximize $U=U(C_m, C_i, C_f; \delta_h)$ (1)

Subject to:

$I = wT+I_e-wF-P_xX-P_mC_m$ (income constraint) (2)

$G(Q,F,X;\beta_f) = 0$ (technology constraint (3)

$F+L_d+C_i = T$ (time constraint) (4)

Equation (1) represents the utility function of a representative household while Equation (2) gives the full income budget constraint. Full income (I) is composed of the value of the stock of total time owned by the household T, exogenous income I_e, the values of household management input used in the banana farm production F, other variable inputs required for production of farm outputs, X, and market commodities consumed by the farm family, C_m. The household faces a production constraint with regard to production technology on the banana farm which is given in Equation (3). It gives the relationship between farm inputs F, X and all outputs Q, and has the properties of quasi-convexity, increasing in outputs and decreasing in inputs (Taylor and Adelman, 2003). The vector β_f represents the fixed agro-ecological features of the banana farm, such as soil quality and land characteristics. The household also faces a time constraint (Equation 4) as labor use in banana farm cultivation F is one use of labor which competes with other uses, including off-farm employment L_d and leisure C_l.

The household is driven towards the goal of increasing diverse farming within the family farm because of uncertainty and unreliable or missing markets as well as the desire to consume fresh food. In this instance, it is required to consider a market constraint as an additional constraint. Assume that Q_f and C_f denote the quantity supplied and consumed of farm products and Z is a vector of exogenous characteristics related to availability and access to the market. Accordingly, $Q_f - C_f(Z) > 0$ becomes the additional income constraint that needs to be added. It shows the surplus of the demand and supply of the respective good. This surplus in terms of revenue can be written as $[Q_f - C_f(Z)]P_0$ where P_0 is the output prices of banana products which gives the total revenue that farmers receive from producing the commodity, which is banana in this study.

The household maximizes utility subject to constraints as explained in Equations 2, 3 and 4. This maximisation results in the following Lagrangian:

$$L=U(C_m,C_i,C_f;\delta_h)+ \lambda (wT + I_e - wC_i - P_m C_m - wF - P_xX)$$
$$+p\ [Q_f - C_f(Z)]+ \mu G(Q_f,F, X; \beta_f \qquad (5)$$

However, when all relevant markets function perfectly, farm production decisions are made separately from consumption decisions (Birol, 2004). In such a context, full income in a single decision-making period is composed of the net farm earnings (profits) from crop production *(Qf)*. The household maximizes the net farm earnings subject to constraints as explained above and then allocates these along with other income among consumption goods (Smale *et al.* 2001; Karunarathna, 2012).

Assuming a well-behaved utility function, the optimal set of choice variables is given by the solutions to the first order conditions of the Equation (5). The general solution to the household maximization problem yields a set of optimal choices for production, inputs demand, and consumption demand. Equation (6) gives the optimal solution for banana outputs:

$$Q_f = Q_f(Pm, Px, w; Q_h, \beta_f, Z) \qquad (6)$$

We assume that the household does not value diversity itself but rather its direct benefits. We, therefore, do not include diversity explicitly in the utility function. The diversity within a given household is the result of the choices made regarding which varieties to cultivate subject to constraints. This means that diversity outcome in the constrained case takes the form of a derived demand for a number of varieties resulting from the farmer's utility maximization subject to income, production, and market constraints. Following Van Dusen and Taylor (2005), the level of diversity maintained on the banana farms, which is a direct outcome of the production and consumption choices of the farm household, is a function of all prices as well as characteristics of the households, markets, and the farm plots. Equation (7) specifies this relationship:

$$BD = BD \{Q^{*}_{f} (P m , P x , w; Q_{h}, \quad \beta_{f,} Z)\} \tag{7}$$

The banana diversity equation used in this study is similar to the ones used in Brush *et al*. (1992), Meng (1997), Smale *et al*. (2001) and Birol (2004). Some of the interesting applied economic analyses of diversity are found on the farm household model or a model of variety choice are Brush *et al*. (1992), Meng (1997), Smale *et al*. (2001) and Birol (2004)

3. Empirical Approach

In order to understand the important determinants of banana variety selection by farmers we selected different types of policy-relevant variables. We inferred the importance of these variables from the information gathered by the researchers from the focus group discussions as well as information provided by the agricultural officers in the survey area. All collected variables were divided into three main categories, namely, household characteristics, market characteristics and other characteristics. Table 1 provides the definition of all variables used in the regression analysis.

We use two different measures for diversity. First a simple richness measures or counts of the number of banana varieties the household plants is used as the basic measures of species diversity at the farm level. As an alternative method, SDI was estimated for number of bushes. The advantage of the SDI over the count of varieties is that it takes account of the amount of each variety. If the share of bushes of a given variety is very small, it will add very little to the SDI, but it increases the count by as much as a variety that accounts for most of the bushes. In the first case, the dependent variable (i.e., the number of species) is a count variable that takes on nonnegative integer values. Therefore, we use the Poisson regression model as the first stage model to analyse the data. In the empirical setting, this model is typically used either to summarize predicted counts based on a set of explanatory variables, or for the interpretation of exponentiated estimated slopes (i.e., difference in the incidence rate ratio) of the outcome based on changes in one or more explanatory variable (Greene, 1997). In this study,in order to estimate the farmers' preferences with regard to banana diversity, we first used Poisson regression with robust standard errors and clustering standard errors at the village level. We also ran a village-level fixed-effect model in order to control for village-level unobservable characteristics that affect variety selection.

In order to capture the species diversity of banana, we constructed the Shannon Diversity Index (SDI) which accounts for both abundance and evenness of the species in the study area. It is created by considering the number of bushes for each banana species. Equation (8) explains the basic equation for the SDI:

$$SDI = - \sum^{n}_{i=1} (P_{i} * In\ P_{i}) \tag{8}$$

where, SDI refers to the Shannon Diversity Index, P_i is a fraction of the total number of bushes making up species i, n is the number of species encountered, and $\sum$ indicates the total of the species in a given farm.

After obtaining the SDI value for each farmer, we used these values as the dependent variable in the OLS model. We ran specificas well as general versions of the models by setting robust standard errors and village-level clustering. The empirical model is as follows:

$$Y_{i} = \beta_{0} + \sum_{j=1}^{32} \beta_{j} X_{j} + U_{i} \tag{9}$$

where Y_i is either a count dependent variable or SDI that represents the diversity indices, namely, the number of banana species, while all other independent variables are as explained in Table 1. All these independent variables are based directly on the questionnaire responses. Table 1 makes it clear that while some variables take the form of numbers, the other variables are defined as dummy variables. We explain the rationale for using different variables and their expected signs below.

Family size is one of the important variables used in this study. In general, the number of members in the family is expected to have a positive effect on diversity as a more diverse system requires more labor (Keller *et al*. 2006). This variable shows labour support that is available within the family for their farming and more active household labour in agriculture generally contributes positively to crop diversity. We expect education to have a positive relationship with the number of varieties as more educated farmers would easily understand the benefits of maintaining diversity on their farms[3]. Experience in farming is another important variable used in the analysis. According to Van Dusen (2000), the experience of the household head in agricultural activities has a quadratic relationship with selection of a diverse farming system. Land size is another variable used in the variety selection model. We anticipated the size of the agricultural land to have a positive relation with the number of varieties grown as land size can relax the constraint on trying out different varieties on the farm (Gauchan *et al*. 2005). It is expected that the information availability on banana market prices as well as satisfaction relating to the price they receive to have a positive relationship with the number of varieties. With more information, farmers understand the value of cultivating different varieties on their farms.

We include a direct sale variable in order to see whether it has an impact on the selection of banana diversity on the farm. The expected sign of the coefficient of this variable is positive since the ability to sell their output to the market directly yields a relatively higher return to the farmers which functions as an incentive for them to maximise the benefits by cultivating different varieties. On the other hand, if farmers have to sell their output through intermediaries, their relative gain is less; hence,there is little incentive to maximise revenue by cultivating different varieties. Distance to the nearest market is another important variable used in the study. We hypothesize that when distance to the nearest market is higher, farmers are less likely to maintain a diverse system within a single crop[4] as any form of market constraint makes them less likely to have a diverse output for market (Birol *et al*. 2008). We use two variables in this analysis to capture farmers' knowledge on modern banana varieties such as GM and high-yielding varieties. We also include several variables relating to farmers' attitudes towards banana cultivation. We create four dummy variables from the following two statements on the number of banana varieties: (a) that they make the landscape more beautiful and (b) that they represent our cultural heritage.

Farming decisions involve risk (Villano and Fleming, 2006). For example, if a farmer decides to cultivate a particular crop variety in a particular season, bad weather conditions can give him a lower yield resulting in lower incomes during that season. In order to better understand how famers factor in risk in their decisions, we introduced a simple coin flipping game where there was a real chance of winning some money. The game involved a choice between the certainty payment of LKR 100 for not playing the game and the uncertainty involved in playing the game to win LKR 200 or none depending on the flip of a coin. We asked those who opted to play the game a follow-up question which offered those of them who won a choice between getting the money (LKR 200) now or waiting for 30 more days to receive an additional 20 percent on the sum (i.e., LKR 240) using local enumerators as guarantors for the late but higher level of payment (Donkers *et al*. 2001).Using this information, we included two variables to see whether risk preference has some impact on variety selection. In this case if farmers accepted fixed amount of money, we use one or otherwise zero. We also created dummy variables to differentiate between district heterogeneity.

[3] However, impact of education on diversity can show the opposite results as well. In that case, more educated farmers may also be better equipped to specialize in a few modern varieties.

[4] This argument does not quite obtain in the case of multiple crops where more isolated farmers have incentives to maintain a more diverse farming practice.

These models describe statistically the farm households that are most likely to sustain observable levels of banana diversity. Significant variables in these models will provide important insights into the parameters that policy-makers ought to take into account in order to design policies in the crop concerned. The predictions based on the econometric model enable us to profile the households that are most likely to sustain current levels of banana diversity because they reveal the greatest preference for them.

3.1 Study area and sampling

We purposively selected the three districts of Ampara, Kurunegala and Ratnapuraout of the 26 administrative districts of Sri Lanka for this study (see Figure 1). In selecting the districts, we took into consideration their contribution to the total banana production in the country and representation of different climatic zones. There is significant heterogeneity among the farms from the 3 different districts as they are located in different climatic zones of the country. Not only do the three districts make a significant contribution to banana production in Sri Lanka but a majority of the people of the 3 districts cultivate banana for their livelihood. According to a survey conducted by the Department of Census and Statistics (2012), the total number of scattered banana bushes in Ampara were around 0.4 million in Kurunegala 1.4 million and in Ratnapura 0.8 million. In Ampara district, 62 percent of the total number of banana bushes were cultivated in plots that were more than quarter of an acre in size while the figures were 79 and 69 percent, respectively, for the Kurunegala and Ratnapura districts. Moreover, the three districts together contribute 15 percent of the total banana production in Sri Lanka. According to the Department of Census and Statistics(2012), the average size of the commercial banana farm in the three districts is 1.5 acres.

We selected one District Secretariat (DS) division per district for our study, namely, Uhana in the Ampara district, Embilipitiya in the Ratnapura district and Ganewatta in the Kurunegala district. We took into account three factors when selecting a DS division from each district: the extent of commercial banana farming, the diversity in banana farming, and accessibility of farmers to information from the DS secretariat. We found that there were significant differences among farms coming under the different DS divisions with regard to banana varieties (i.e., species diversity) which enable us to capture the determinants of farmer preferences with regard to different varieties of banana in the study area. We expect the farms in these DS divisions to represent banana farms in Sri Lanka for the purpose of generalizing our findings. Of the selected DS divisions, we prepared a list of banana-growing *Grama Niladari* (GN) divisions by taking into consideration the number of banana growers who cultivate more than a quarter of an acre. We base the decision to include a particular GN division in the sample on whether at least 10 farmers cultivate more than a quarter of an acre of banana individually. The selection was done with the help of agricultural extension officers and village-level administrative officials. Figure 2 explains the basic structure of sample selection.

We selected 71 villages which satisfy the above conditions. From the selected villages, a list of banana growers who cultivated more than a quarter of an acre of banana individually was prepared. We then adopted a simple random sample procedure to select the sample from each DS division. First, we assigned numbers to farmers in the division which were written on pieces of paper and thrown in a large ball from which 160 numbers were randomly selected for each DS division. As can be seen, though there were more villages in all DS division in all three districts, the survey covers only 68 villages. Table 2 gives a summary of the selected DS divisions, the selected GN divisions, and details of the banana growers. The following section gives further details on the survey implementation.

3.2 Survey implementation

The survey took place in several stages, namely, focus group discussions, pilot survey and final survey. The aim of the pilot study was to test the feasibility of the questionnaire in terms of language or wording issues and to gauge whether all farmers understood the questions in the same way so that revisions could be made to the questionnaire if necessary prior to the main survey. We conducted the pilot survey in August 2014 while the main survey was conducted from the beginning of September till the end of October 2014. In all three districts, we administered the questionnaire to the head or other working member of the household in a face-to-face interview.

We designed the questionnaire to capture the various aspects to banana farming practices that had been validated in the pilot survey. The survey was carried out by 10 enumerators (university undergraduates) who were given a thorough training on all aspects of data collection before being sent to the field. The interviews took place in the interviewee's home. The enumerators were instructed to inform the participants about the purpose of the study and to ask for consent prior to interviews. A field supervisor reviewed the quality of the data gathered before entering them into a database for analysis.

4. Results and Discussion

The following section explains the most important socio-economic variables of the respondents and their families since this information is of importance in estimating the models.

4.1 Sample characteristics

The total number of banana farmers selected for the final survey were 480 (160 farmers from each district). Excluding a few incomplete questionnaires, a total of 450 questionnaires–data from 150 households from each district–were available for the analysis. Table 3 and 4 give the descriptive statistics of the respondents and their perceptions of banana cultivation. Of the respondents, 81 percent were male while 19 were female. The average age of the respondents was 47 years while their average experience as farmers was 11 years for the entire sample. The main income source of the families came from agriculture. Approximately 60 percent of the respondents identified banana farming as their main income source. The average monthly agricultural income was LKR[5] 37,000 while the bulk of the household expenditure was on food, followed by health and personal care, and transport.

The average family size was approximately 5. Although agriculture was the main source of household income, income from non-farm activities such as micro-level business, government or private sector employment, working as casual or daily wage laborers and interest earned from money-lending accounted for almost 20 percent of the total household income. All respondents were literate, the average number of years of education being grade nine and the minimum level of education being grade two. Roughly 78 percent of the respondents had passed grade 5 in school while 52 percent of the respondents had passed the G.C.E. Ordinary Level examination. Such relatively high education levels may help explain the reliable results yielded in this study.

Banana, which was cultivated as the main agricultural crop by 60 percent of the farmers, was followed by various types of vegetables and cash crops such as tomatoes, paddy, chilli and onion. The maximum number of banana varieties cultivated by any farmer was eight. We found 18 varieties and of them seven (*Rathambala, Nadee, Pulaathisi, Mondan, Atamaru, Suwandal and Meti Kithala*) are traditional varieties while others (*Seeni Kesel, Ambun, Embul, Anamalu, Bin Kesel, Kandula, Kolikuttu, Prasad, Ash Plaintains, Puwalu and Nathran*) are commercial varieties. Approximately 36 per cent of the farmers cultivates traditional varieties. Approximately 28 percent cultivated only one variety while 26, 10, 11, 9 and 14 percent cultivated 2, 3, 4, 5 and more than 5 varieties, respectively, in all the districts. The average size of the banana farm was 1.5 acres while the average distance between the banana farm and the house of the farmer was 500 meters. The average annual quantity of banana sold by farmers was 18,000 kg. Their annual average household consumption was 72 kg. The average annual income of a banana farmer in the study area was LKR 406,000 which earns him a monthly income of LKR 34,000 which is relatively higher than that earned from paddy cultivation or other cash crops (paddy - LKR. 16,750 p/m and chillies - LKR. 8,300 p/m). The average expenditure excluding labor expenses for cultivating banana is LKR 32,000 per year. If the value of the labor used in cultivation were to be added, which comes to LKR 50,000 per year, the annual total cost of banana cultivation comes to LKR 82,000. This shows 61 percent of the total costs to be labor-related which is approximately similar to that of other crops such as vegetable and paddy. In the sample, the average labor usage was 62 man-days. This is to be expected given the tedious and labor intensive work required throughout the banana cultivation period. Usage of external inputs was low (at LKR 9,200 as capital per year) given the small size of the farms in the study areas. Accordingly, the average monthly expenditure for a banana-growing farmer was around

[5] Exchange rate USD 1 = LKR 131.25 in 2014

LKR 6,800 which gives a rough figure of LKR 27,000 as the monthly profits from cultivating banana in the study area[6].

As mentioned before, we attempted to assess the farmers' risk-taking behaviour via an experiment. The experiment shows that of the number who accept the safety payment and those who win the toss, 60 percent wanted to take money immediately rather than wait for one more month. We also asked farmers to rank their risk-taking behaviour on a scale of 1 to 10 and Figure 4 gives the data on self-assessment by farmers of their predilection for taking risks. These risk-taking preferences are reflected in their choice of banana cultivars. Out of 29 banana cultivars, we found only 18 species in the study area. Figure 3 gives details of these species. Approximately 54 percent of farmers in the study area cultivate the banana variety called *Ambul (mysore)*, which is commonly found and easy to cultivate in Sri Lanka. *Seeni Kesel* and *Kolikuttu* are the next popular varieties with approximately 54 and 48 percent of farmers cultivating these two varieties. Figure 3 clearly shows that the number of farmers cultivating certain varieties of banana is very small. For example, we found that less than five percent of the farmers opted to cultivate traditional varieties such as *Suwandal, Nathran, Meti Kithala, Nadee and Pulathisi*. This shows that while commercial varieties are gaining in popularity in the country, traditional varieties are gradually losing ground to them and disappearing from society through neglect.

4.2 Farmers' attitudes toward banana diversity

The questionnaire carried some questions that attempted to gauge farmer attitudes to different banana varieties and banana cultivation practices. Approximately 74 percent of the farmers believe that greater variety in terms of banana species enhances the beauty of the landscape and that traditional banana varieties represent Sri Lanka's cultural heritage (see Figure 5). 71 percent also mentioned that environmentally-friendly farming practices reflect principles and values that are of importance to them which indicate that farmers harbour positive attitudes towards environmentally-friendly farming practices. However, when the question was posed whether environmentally-friendly farming practices help improve consumers' perceptions of farmers, only 57 percent agreed. Roughly 50 percent of farmers thought that benefits of conserving banana diversity are long term while 49 percent believed that banana diversity helped to decrease the farmer's risk of fluctuating income. 54 percent of respondents mentioned that more varieties of banana on their farm would help increase the farmer's income.

Table 4 presents household perceptions regarding the different aspects of banana cultivation. The survey results reveal that while 63 percent of the respondents had heard of the high yielding varieties, only 45 percent were aware of the GM varieties (Figure 6). We posed a different set of questions on GM varieties to farmers who had heard about GM varieties. Figure 7 summarises this information. Approximately, 75 percent of these respondents accepted that GM varieties yield more than traditional varieties. Further, 64 and 52 percent of the respondents mentioned that GM varieties have the ability to resist specific diseases and pests compared to traditional varieties and that the former thus has better survival rates than traditional varieties. However, only 25 and 36 percent respectively of farmers mentioned potential adverse health outcomes stemming from consuming GM varieties and adverse environmental issues associated with cultivating GM varieties[7].

4.3 Determinants of variety selection

As explained in the previous section, we use species richness measures (SDI) or counts of the number of banana varieties the household plants as our basic measure of species diversity at the household level. In order to model crop species diversity, we use a Poisson regression model because of the discrete, count nature of the dependent variable. Marginal effects[8] of these models are the change in the expected number of varieties for one-unit change in an independent variable (Greene, 1997).

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[6] Average 1.5 acres

[7] Farmers do not cultivate GM varieties in their farms which is a good indicator of their attitudes towards GM varieties. GM banana varieties are not available in the country. However, few high yielding varieties are cultivated by several Agro-companies in Sri Lanka.

As an alternative measure, we estimated SDI for the number of bushes. We first estimate the models including variables such as family size, education, experience, land extent, awareness, satisfaction and distance. Then we estimate the more general models including attitudes, risk preference and district dummy. We also use both robust standard error and clustered robust standard error at the village level to see whether there are any deviations in the results from each other. In addition to this, we estimate a village-level fixed-effect model to control for village-level unobservable characteristics that may affect variety selection. Table 5 gives the estimated results of the Poisson regression models. They make it clear that the results of the different versions of the models are almost similar in terms of the coefficients, signs and their significant levels.

The results of the study show that family size is significant and has a positive impact on banana diversity. This variable shows the labor support that is available within the family for farming (Van Dusen, 2000; Gauchan *et al*. 2005). We expect more active household labor in agriculture to generally contribute positively to crop diversity[9]. The education level is significant and has the expected sign in all four models (Hengsdijk *et al*. 2007; Birol *et al*. 2008). Experience in farming is significant in all models too and shows a positive coefficient value. This implies that the farmers who have more experience in farming are likely to maintain a more diverse farming system as they may have a better understanding of the benefits of a diverse farming system than less experienced farmers. The results also show larger farms to be associated with greater diversity (Keller *et al*. 2006; Hengsdijk *et al*. 2007). The influence of this variable is uniform and significant across all models which shows the robust nature of this variable.

The relationship between market characteristics and diversity is complex. We have included four market-related variables: (i) level of awareness of farmers about banana market prices, (ii) availability of direct sales, (iii) distance to the nearest market, and (iv) satisfaction about market prices. It is noteworthy that farmers who receive market information were more likely to have diverse farming practices. This could be attributed to the fact that farmers who receive market information may also be knowledgeable about prices, the possibility of fluctuation of prices, and the optimum quantities of varieties to cultivate in a given season. This would in turn inform decisions on their part to increase or decrease the number of varieties cultivated in order to minimize risk. The variable related to the marketing method that farmers use (i.e., whether to the village trader/shop, directly to the city, or intermediate trade/others) is significant in all models. Farmers' satisfaction about prices is significant too and has the expected sign in all the models. This implies that the greater the satisfaction of the household, the more likely the household is to plant a diverse set of banana varieties.

The distance to the market is significant in all models. However, the coefficient of this variable is positive implying that when the distance to the nearest market is greater, farmers are likely to maintain more diverse banana farms. In general, the operations of market infrastructure on the maintenance of diversity on farms can be several. On the one hand, when households are isolated from a major market centre, the costs of buying and selling will be relatively higher which would make them more likely to rely on their own production for subsistence. This implies that the more physically isolated a community or household is, the less specialized would be its production activities (Birol *et al*. 2008). On the other hand, when market facilities reach a village, new trade possibilities would emerge, opening up new opportunities for engaging with market activities (Smale *et al*. 2002). The theory on the household farm predicts that the higher the transactions costs faced by individual households within communities, the more they would rely on the diversity of their crop and variety choice to provide the goods they consume. Consistent with this hypothesis, Van Dusen (2000) has found that the more distant the market, the greater the number of maize, beans, and squash varieties grown by farmers. In Andean potato agriculture, Brush *et al*. (1992) found proximity to markets to be positively associated with the adoption of modern varieties but this adoption did not necessarily decrease the numbers of potato types grown.

[8] The marginal effect of one covariate is the expected instantaneous rate of change in the dependent variable as a function of the change in that covariate while keeping all other covariates constant (Greene, 1997).

[9] We also created two variables, one being the number offamily members between the ages of 15 and 65 and the other being the total number of family members whose age is less than 15 and greater than 65. We found that both variables have the same signs with significance suggesting that there is no significant impact of family members' age on the selection of the number of varietiesare not available in the country. However, few high yielding varieties are cultivated by several Agro-companies in Sri Lanka.

We have included several variables to capture farmers' attitudes towards the number of varieties selected. The variable *GM* variety tests whether farmers have heard of GM banana varieties or not. This variable is significant in both models with the negative sign. It is a proxy to assess farmers' awareness of modern farming practices, the implication being that farmers who are aware of GM varieties would be more likely to maintain a fewer number of varieties on the assumption that specialization would generate more income. However, the variable on high yielding varieties, which is included in the model on the basis of this assumption, is not significant. Four dummy variables based on two statements, (a) the number of banana varieties contribute to the beauty of the landscape and (b) traditional banana varieties represent our cultural heritage are statistically significant. Interestingly, farmers who believe that banana diversity helps to decrease their risk were more likely to cultivate more varieties in comparison with those farmers who answered "Not Sure". Furthermore, both dummy variables relating to the statement that having more varieties of banana on the farm would help to increase the farmers' income show significant and expected signs. Accordingly, farmers who believe that having more varieties of banana on the farm would help increase their income due to diversity outcomes are more likely to cultivate more varieties in comparison with the group of farmers who answered "Not Sure"[10]. The coefficient relating to farmers who disagree with this statement also carry the expected sign which is statistically significant which means that farmers who do not believe that having more varieties of banana on the farm would help increase their income based on diversity outcomes are less likely to cultivate more varieties in comparison with the group of farmers who answered "Not Sure". The results of our study indicate that risk-averse farmers are more likely to cultivate more varieties. Price fluctuation on inputs and outputs of banana cultivation is a common phenomenon in Sri Lanka. This could be the reason why risk-averse farmers cultivate more varieties than other farmers. For example, in a given season, the price of one variety may decrease while the price of another variety may increase or at least remain constant. If farmers have cultivated several varieties, they can reduce the risk of losing income due to such fluctuations. The results also show heterogeneity among districts relating to banana cultivation practices to be significant. This is to be expected as we have selected three districts representing different climatic zones in the country where different varieties would be cultivated with differentiated input requirements, yields and market values.

As discussed in the section on methods, the Shannon Diversity Index is created by taking into consideration the total number of bushes in each species of banana. We therefore ran four models separately by controlling the different variables as well as under robust and clustered standard error. Table 6 gives the results of the three models. The results for the OLS model show that variables such as family size, education and experience which represent household characteristics have the same signs as Poisson regression results. These variables are highly significant in all models. The size of the farm is also significant and has the expected sign in all four models. Similarly, the variables relating to market characteristics are highly significant and take the expected signs. As with Poisson regression results, most of the attitude variables are not significant. However, ***reduce risk_1 and income_1*** variables which represent (a) banana diversity by farmers help to decrease their risk and (b) having more varieties of banana on the farm helps to increase a farmer's income due to diversity outcomes are significant in both the models. The coefficients of these variables are positive and statistically significant under the one percent level. This implies that farmers who believe that diverse banana farms would increase their income are more likely to adopt more diverse farming practices. The results relating to the risk variable and district dummy are almost the same as for Poisson regression results. The similarities in the results of all the models deployed imply the robust nature of our study.

5. Conclusions and Policy Recommendations

This study is among a handful of studies in the literature that attempts to assess farmer preference for Banana varieties in developing countries. The results indicate that maintaining on-farm diversity is beginning to receive increasing attention from farmers as a strategy for mitigating production risk and protecting food security in the rural areas of Sri Lanka. Our findings also yield information of importance to policy-makers interested in increasing banana diversity in Sri Lanka. Firstly, given that household and individual characteristics, including family-size, farm

[10] We do not find a significant correlation between the variable 'satisfaction' and market price.

size, education and experience of farming are major determinants of the number of banana varieties on farms, any awareness-raising exercises by officials should make large families with large land holdings and educated and experienced farmers their first priority.

Secondly, the study shows that expansion in the number of banana varieties cultivated is possible if farmers are provided with information on the market for bananas and assured of a satisfactory market price for each variety. Thirdly, existing land market regulations[11] are one important reason for the prevalence of small farming plots among banana farmers. Since land extent is positively correlated with diversity according to the findings of our study, relaxing or reforming existing regulations to expand land extent will undoubtedly have a positive impact on banana diversity in the country. Hence, actions on the part of policy makers to reform land market regulations to make it possible for farmers to own large scale farms is essential for any future improvements in banana variety diversity. Finally, regional heterogeneity has emerged as a strong factor in each statistical analysis conducted, whether descriptive or econometric, in our study. Hence, any agro-environmental policy or program the aim of which is to improve the current levels of banana diversity in Sri Lanka would need to recognize the heterogeneity of these farms in terms of their geographical location or physiographic variations.

Thus the findings of this study would be useful in arriving at appropriate policies to conserve banana diversity in Sri Lanka because the study reveals factors, such as households, markets, availability of information, and existing land regulations, which require attention on the part of policy-planners when designing programs or policies to conserve or enhance banana diversity in Sri Lanka.

Acknowledgments

The authors are grateful to Jeff Vincent, Rajesh Kumar Rai, Priya Shyamsunder, Mani Nepal and the other resource persons, including SANDEE associates, for encouragement at various stages of this study. The authors also acknowledge the valuable logistical and financial support provided by the SANDEE Secretariat. We are also grateful to Mihirangi and Ayesha for rendering valuable service during field supervision. Our special thanks go to the enumerators, field monitors and rural households of the survey areas for their keen participation in this research.

[11] At present, land distributed by the Land Development Authority cannot be leased, mortgaged or sold in rural areas in the country. Further, in general, no clear deeds are available for most land in rural areas, which is a constraint on developing land market.

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Tables

Table 1: Explanatory variables used in the variety selection model

Variable	Definitions
Household Characteristics	
family size	Number of household members in the family
education	Education level of the respondent (no. of years)
experience	Experience as a banana farmer (number of years)
landsize	Size of the total land owned (acres)
Market Characteristics	
informed	How well informed are you of banana market price? :Dummy variable
	1 if very well or well;0 not so well or not well
marketing	What is the most common way of marketing your harvest?: Dummy variable
	1 if village trader/shop or directly to the city; 0 intermediate trader or others
satisfaction	Are you satisfied with the prices that you have received during the last season? : Dummy
	variable1 if satisfied; 0not satisfied or don't know
distance	Distance to the Nearest Market(km)
Other Characteristics	
GM variety	Have you ever heard about the GMbanana varieties: Dummy variable
	1 if Yes; 0 No
hybrid variety	Have you heard about the following high-yielding varieties: Dummy variable
	1 if Yes; 0 No
	Banana varieties makethe landscape appear more beautiful: Dummy variable
	1. Agree 2. Disagree 3. Not sure
view_1	1 if agree, 0 otherwise
view_2	1 if disagree, 0 otherwise
	Traditional banana varieties represent our cultural heritage:Dummy variable
	1. Agree 2. Disagree 3. Not sure
cultural value_1	1 if agree, 0 otherwise
cultural value _2	1 if disagree, 0 otherwise
	Banana diversity helps to decrease the farmer's risk:Dummy variable
	1. Agree 2. Disagree 3. Not sure
reduce risk_1	1 if agree, 0 otherwise
reduce risk_2	1 if disagree, 0 otherwise
	Having more varieties of banana in the farm helps to increase the farmer's income:Dummy
	variable
income_1	1 if agree, 0 otherwise
income_2	1 if disagree, 0 otherwise
risk preference_1	Accepted fixed amount of money or agreed to game: Dummy variable
	1 if accepted money, 0 otherwise
risk preference_2	Self-ranking about risk : Dummy variable, 1 if 0-5, 0 otherwise
district_D1	District dummy variable, 1 if Kurunegala, 0 otherwise
district_D2	District dummy variable, 1 if Ratnapura, 0 otherwise

Note: More details of the variables are available in the questionnaire in the Appendix.

Table 2: Details of selected villages for the final survey

District	DS Division	Number of Main Banana Growing Villages	Total Number of Banana Growers	Selected Sample
Ampara	Uhana	18	412	160
Kurunegala	Ganewatta	28	631	160
Ratnapura	Embilipitiya	25	687	160

Note: Banana growers include only farmers that grow banana for commercial purposes. Though we have selected 71 villages, only 68 villages have been included in the survey from the random sampling process.

Table 3: Descriptive statistics of the socio-economic variables

Variable	Mean	Std. Dev.	Min.	Max.
SDI Index (bushes)	0.72	0.59	0	2.02
Number of varieties (no.)	2.98	1.96	1	8
Banana farm size (acres)	1.53	0.72	0.25	3.8
Family size (no.)	4.44	1.83	1	10
Education(years)	8.99	3.36	2	13
Experience as a farmer	11.24	8.75	1	42
Extent of agricultural land (acres)	2.16	0.92	0.25	5.75
Distance to market (km)	5.67	7.35	0.01	35
	Yes (%)	No (%)		
Well-informed about banana marketing price	50.67	49.33		
Marketing directly	54.61	45.39		
Satisfied with the prices	34.22	40.89		

Table 4: : Attitudes towards banana cultivation (percentage of responses)

Sentence	Agree	Disagree	Not sure
Number of banana varieties makes the landscape appear more beautiful	74	17	9
Traditional banana varieties represent our cultural heritage	75	10	14
Environmentally-friendly farming practices reflect principles and values that are important to me	71	13	16
Environmentally-friendly farming practices help improve consumers' perceptions of farmers	57	21	22
Most benefits of conserving banana diversity are long term	51	23	26
Banana diversity helps to decrease the farmer's risk	47	28	25
Having more varieties of banana in the farm helps to increase the farmer's income	54	19	28
GM varieties have more yields than traditional varieties	75	13	13
GM varieties have the ability to resist specific diseases and pests than traditional varieties	63	19	18
GM varieties have a better survival ability than traditional varieties	54	24	21
There are no health issues with consuming GM varieties	25	25	50
There are no environmental issues with cultivating GM varieties	36	25	38

Note: GM variety responses are drawn from 206 responses

Table 5: Marginal effects of the poisson regression models (dependent variable - No. of varieties)

VARIABLES	M1	M2	M3
familysize	0.037***	0.020***	0.047***
	(0.007)	(0.004)	(0.014)
education	0.044***	0.029***	0.069***
	(0.009)	(0.006)	(0.009)
experience	0.003	0.012***	0.046***
	(0.002)	(0.003)	(0.005)
landsize	0.105***	0.039***	0.084***
	(0.016)	(0.010)	(0.027)
informed	0.214***	0.164***	0.271***
	(0.043)	(0.032)	(0.061)
marketing	0.097***	0.035**	-0.044
	(0.022)	(0.017)	(0.047)
satisfaction	0.238***	0.201***	0.589***
	(0.033)	(0.026)	(0.075)
distance	0.025***	0.012***	0.111***
	(0.002)	(0.002)	(0.005)
GM variety		-0.054***	-0.016
		(0.017)	(0.047)
hybrid variety		0.011	0.033
		(0.015)	(0.043)
view_1		0.001	0.018
		(0.034)	(0.073)
view_2		-0.014	-0.071
		(0.037)	(0.083)
cultural value _1		-0.009	-0.033
		(0.024)	(0.056)
cultural value _2		0.015	0.015
		(0.038)	(0.077)
reduce risk _1		0.175***	0.199***
		(0.032)	(0.068)
reduce risk _2		-0.050	0.025
		(0.048)	(0.061)
income _1		0.059*	0.057
		(0.032)	(0.057)
income _2		-0.238***	-0.239***
		(0.049)	(0.068)
risk preference _1		0.054**	0.144**
		(0.026)	(0.064)
risk preference _2		0.025	0.026
		(0.021)	(0.049)
district_D1		0.249***	-
		(0.031)	-
district_D2		0.064**	-
		(0.032)	-
Constant	-0.291***	-0.078	0.345**
	(0.062)	(0.074)	(0.135)
SE Status	Village Cluster SE	Village Cluster SE	Village FE
Observations	450	450	450
No. of Clusters	68	68	68

Note: ***denotes significance at 1% level while ** and * indicate significant variables at the 5% and 10% levels respectively.

Table 6: OLS regression results of Shannon diversity index for number of bushes

VARIABLES	M4	M5	M6
familysize	0.041***	0.025***	0.028***
	(0.009)	(0.007)	(0.007)
education	0.036***	0.022***	0.020***
	(0.008)	(0.006)	(0.004)
experience	0.009***	0.014***	0.012***
	(0.002)	(0.003)	(0.002)
landsize	0.109***	0.043***	0.055***
	(0.017)	(0.013)	(0.013)
informed	0.207***	0.179***	0.156***
	(0.042)	(0.030)	(0.031)
marketing	0.072**	-0.005	-0.013
	(0.028)	(0.021)	(0.023)
satisfaction	0.154***	0.127***	0.136***
	(0.043)	(0.038)	(0.037)
distance	0.021***	0.008**	0.009***
	(0.003)	(0.003)	(0.002)
GM variety		-0.052**	-0.035
		(0.021)	(0.024)
hybrid variety		0.002	0.013
		(0.021)	(0.021)
view_1		0.010	-0.007
		(0.032)	(0.036)
view_2		-0.047	-0.071*
		(0.036)	(0.042)
cultural value _1		-0.036	-0.041
		(0.025)	(0.028)
cultural value _2		-0.004	-0.012
		(0.045)	(0.038)
reduce risk _1		0.111***	0.082**
		(0.040)	(0.034)
reduce risk _2		-0.046	-0.063**
		(0.039)	(0.031)
income _1		0.146***	0.126***
		(0.039)	(0.028)
income _2		-0.154***	-0.171***
		(0.033)	(0.034)
risk preference _1		0.072**	0.097***
		(0.031)	(0.032)
risk preference _2		0.007	0.001
		(0.023)	(0.024)
district_D1		0.149***	-
		(0.055)	-
district_D2		-0.023	-
		(0.040)	-
Constant	-0.433***	-0.113	-0.047
	(0.047)	(0.089)	(0.068)
SE/FE Status	Cluster SE	Cluster SE	Village FE
Observations	450	450	450
R-squared	0.835	0.896	-
No. of Clusters	68	68	68

Note: ***denotes significance at 1% level while ** and * indicate significant variables at the 5% and 10% levels, respectively.

Figures

Figure 1: Extent of agricultural land used for banana cultivation in Sri Lanka

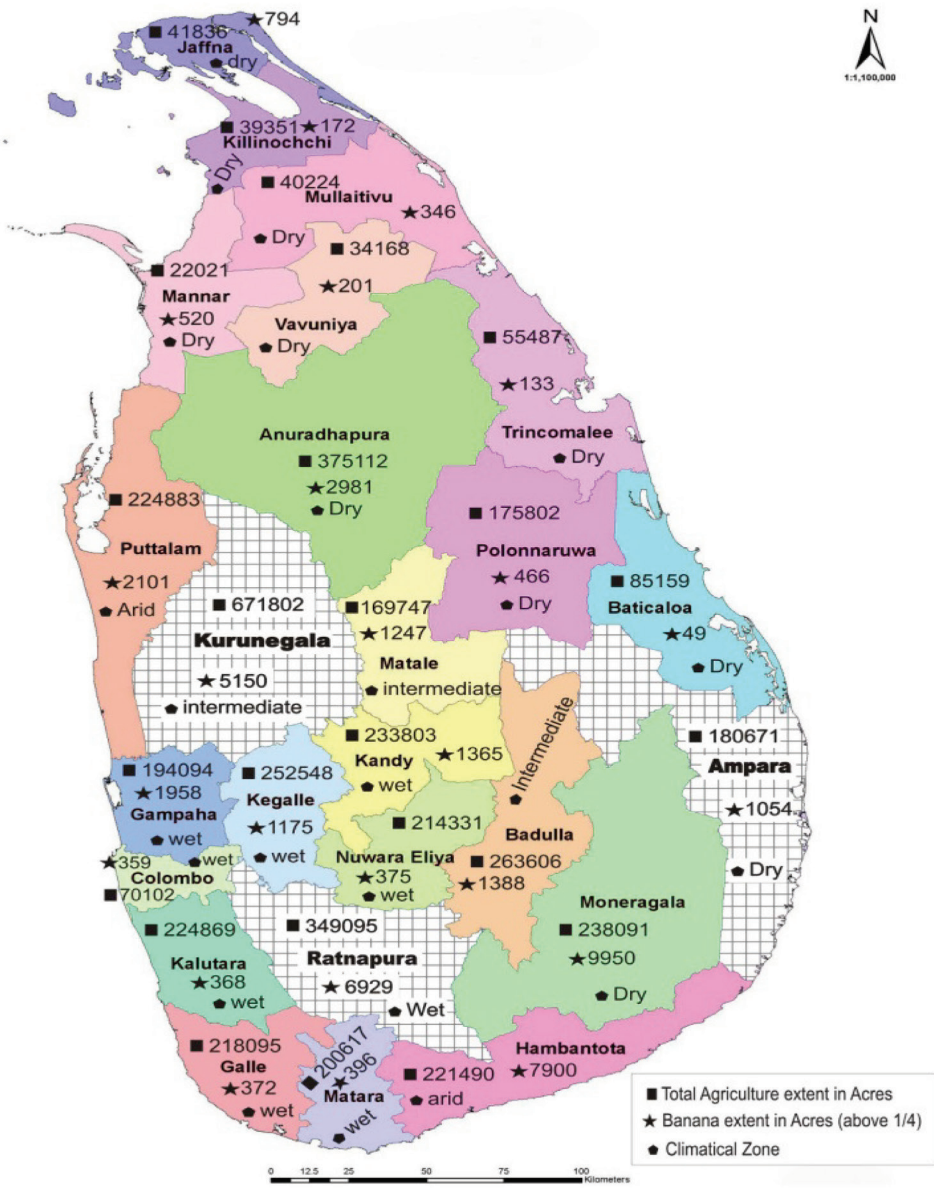


Figure 2: Sample selection procedure

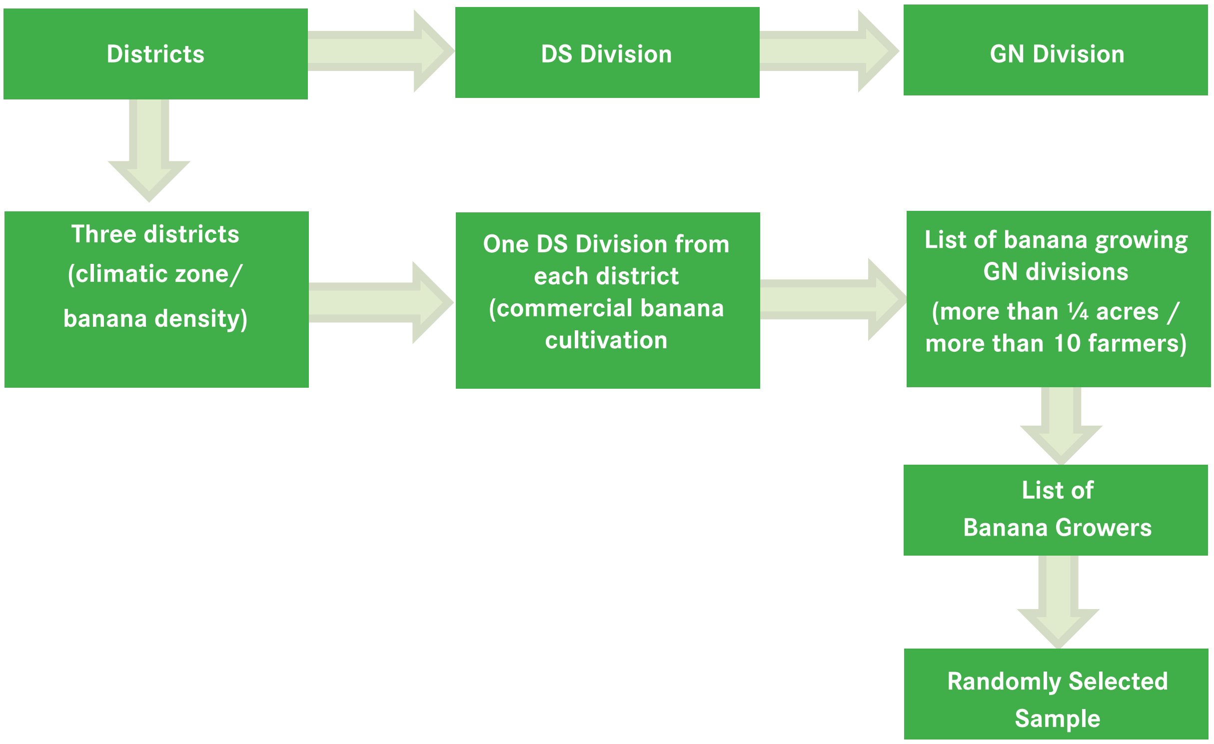
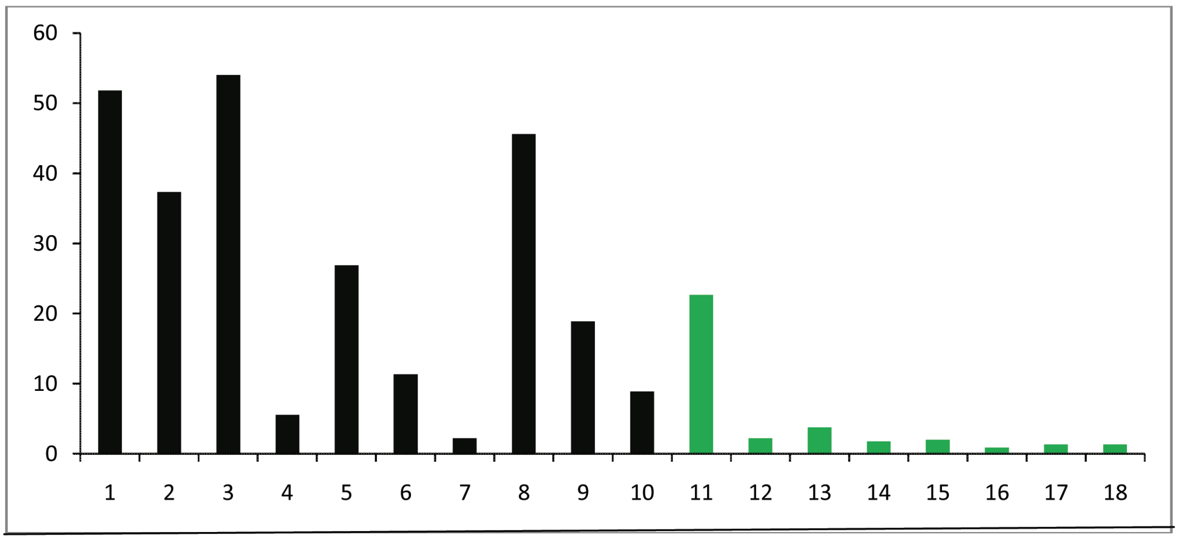


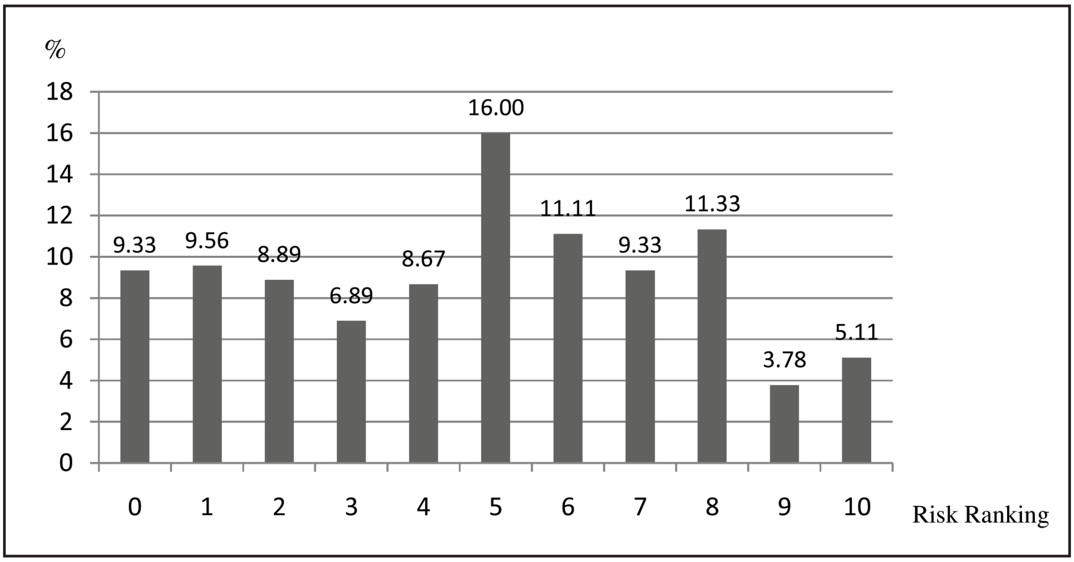
Figure 3: Percentage of farmers who cultivate each banana variety



1 Seeni Kesel(C)
2 Ambun(C)
3 Ambul(C)
4 Prasad(C)
5 Anamalu(C)
6 Bin Kesel(C)
7 Kandula(C)
8 Kolikuttu(C)
9 Ash Plantains(C)
10 Puwalu(C)
11 Rathambala(T)
12 Mondan(T)
13 Atamaru(T)
14 Nadee(T)
15 Pulaathisi(T)
16 Suwandal(T)
17 Nathran(T)
18 Meti Kithala(T)

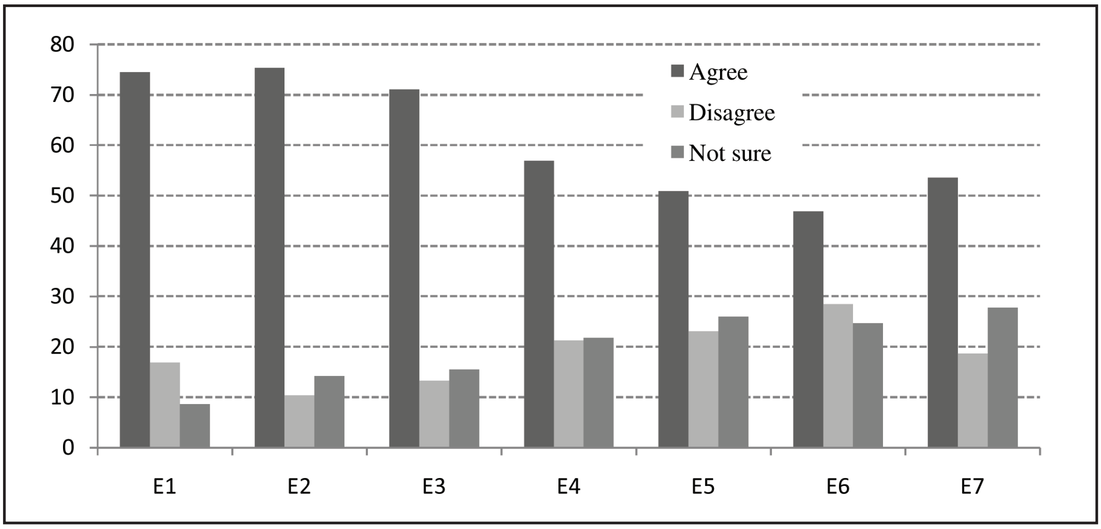
Note: 'C' stands for commercial varieties while 'T' stands for traditional varieties

Figure 4: Percentage of self-ranking about the risk (0 to 10)



Q: Are you generally a person who is prepared to take risks or do you try to avoid taking risks? Please tick a box on the scale, where value 0 means "unwilling to take risks" and value 10 means "fully prepared to take risks."

Figure 5: Farmers' attitudes towards banana farms (percentage)



E1	Number of banana varieties makes the landscape appear more beautiful
E2	Traditional banana varieties represent our cultural heritage
E3	Environmentally-friendly farming practices reflect principles and values that are important to me
E4	Environmentally-friendly farming practices help improve consumers' perceptions of farmers
E5	Most benefits of conserving banana diversity are long term
E6	Banana diversity helps to decrease the farmer's risk
E7	Having more varieties of banana on the farm help to increase the farmer's income

Figure 6: Responses to "have you heard about GM and HY varieties" (percentage)

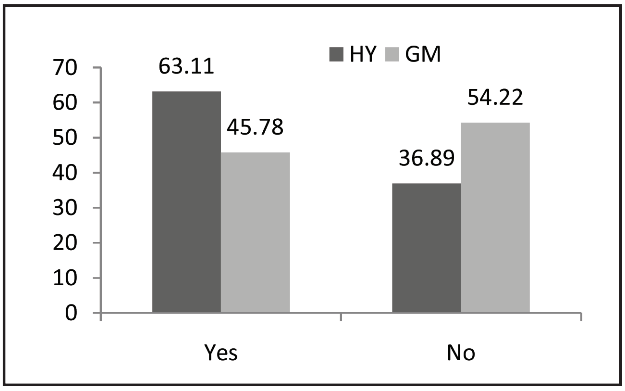
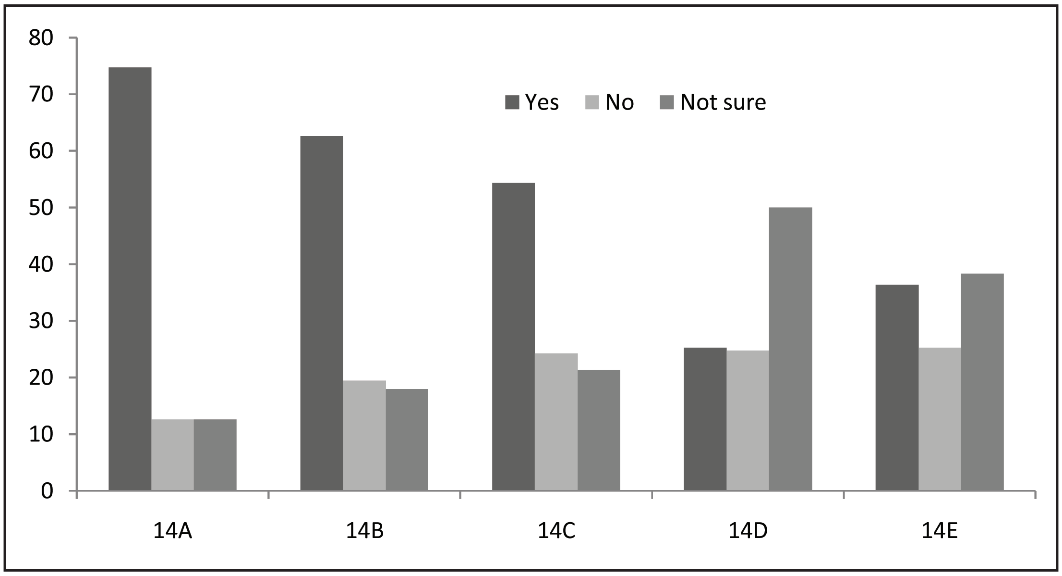


Figure 7: Farmers' attitudes towards GM varieties (percentage)



14A GM varieties have more yields than traditional varieties

14B GM varieties are more resistant to specific diseases and pests than traditional varieties

14C GM varieties have a better survival ability than traditional varieties

14D No health issues with consuming GM varieties

14E No environmental issues with cultivating GM varieties

SANDEE
P.O. Box 8975, E.P.C 1056, Lalitpur, Nepal
Street address: c/o ICIMOD, Khumaltar, Lalitpur, Nepal
Tel: 977 1 5003222, **Fax:** 977 1 5003299, **Email:** info@sandeeonline.org, **Web:** www.sandeeonline.org

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