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*Full Length Research Paper*

# Determinants of agroforestry adoption as an adaptation means to drought among smallholder farmers in Nakasongola District, Central Uganda

**David Mfitumukiza[1], Bernard Barasa[1]* and Aringaniza Ingrid[2]**

[1]Makerere University Centre for Climate Change Research and Innovations, P. O. Box 7062, Kampala, Uganda.
[2]Department of Forestry, Biodiversity and Tourism, Makerere University, P. O. Box 7062, Kampala, Uganda.

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**Agroforestry adoption as a drought adaptation option has an omnibus of opportunities for smallholder farmers in semi-arid regions. This study assessed the severity and frequency of drought and the determinants of agroforestry adoption in Nakasongola District. The episodes were examined using the Standardised Precipitation Index (SPI) set at 3, 6 and 12 months timescales. A cross-sectional survey using semi-structured questionnaires, focus group discussions and key informants were adopted. A total of 200 farmers were randomly selected and studied. The adoption was determined using a binary logistic regression. The SPI results showed that the extreme drought years recorded were 1980, 1984, 1986, 1990, 1995, 1999 and 2000; while the wettest years were 2014, 2012, 2013, 2009 and 2010 as per the 3-time scales. The average return period of severe droughts was 4 years. The levels of agroforestry uptake were higher (85%) between July and June drought period. Agrisilviculture, agrosilvopastoral, silvopastoral and apiculture were the most adopted agroforestry systems by the farmers. The household age, level of education and income were the major significant determinants of agroforestry adoption ($p<0.05$) in adaptation to drought by the smallholder farmers. The potential benefits of agroforestry adoption included the provision of food, fodder, erosion control and soil fertility enrichment, however, the farmers were mainly constrained by inadequate funds, shortage of tree planting stock, limited extension services and information on agroforestry production. Thus, carrying out massive awareness campaigns on agroforestry practices is more likely to increase the uptake.**

**Key words:** Drought, agroforestry, determinants, standardised precipitation index (SPI), adoption, smallholder farmers.

## INTRODUCTION

Drought is a natural phenomenon that occurs when water availability is significantly below normal levels over a longer period; hence the supply cannot meet the existing demands (Wilhelmi and Wilhite, 2002; Zargar et al., 2011;

*Corresponding author. E-mail: barasagis@gmail.com.

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Schwabe and Connor, 2012; Hepworth et al., 2015). This phenomenon can be classified into four major types: Meteorological, agricultural, hydrological and socio-economical drought (Mishra and Singh, 2010; Van Loon and Van Lanen, 2012). In particular, the meteorological drought is the most predominant of all (Wilhite and Glantz, 1985; Quiring, 2009; Wong et al., 2013; Stagge et al., 2015). The effects of these droughts may be estimated basing on the responses of different systems such as agriculture, water resources and forest ecosystems (Vicente-Serrano et al., 2013; Mosley, 2015). For example, in the semi-arid areas of East Africa, these reactions have negatively affected the sustainable agricultural production and thus hampering the food security status of farmers (Ntale and Gan, 2003; Kirkbride and Grahn, 2008; AghaKouchak, 2015). This is because most of the smallholder farmers are unwilling to implement sustainable soil and water measures as drought adaptation responses because drought is perceived as their most significant threat to agricultural productivity much as some have the capacity to adapt within their capacities (Slegers and Stroosnijder, 2008). Some of the implemented short-term adaptation responses by the farmers to the effects of drought are carrying out a holistic land-use planning to apportion the available land to farming and engage in off-farm employment aimed to reduce their vulnerability to future drought conditions (Liverman, 1999; Campbell et al., 2000; Palm et al., 2014). In addition, some farmers have adapted through applying mulches, planting of drought tolerant crop and pasture varieties, carrying out small-scale irrigation, application of organic and inorganic fertilisers and rainwater harvesting which have proved to be more expensive in both short and long-term (Kanyanjua and Ayaga, 2006; Deng et al., 2006; Valencia et al., 2015). However, some of these practices are not based on natural resources conservation and thus dependent on heavy inputs of chemicals which have accelerated the degradation of ecosystems (Victor and Reuben, 2000; Edmeades et al., 2003; Timilsena et al., 2015).

Agroforestry on the contrast puts forth many benefits because it integrates the concept of multifunctionality into practice including biodiversity, food safety, market-oriented production and rural development (Pattanayak and Mercer, 1998; Lasco et al., 2014; Fouladbash and Currie, 2015). Agroforestry is referred to as a management system that integrates trees in the agricultural and non-agricultural landscapes (Nair et al., 2009; Jose, 2012). Agroforestry systems such as agrisilviculture, agrosilvopastoral, silvopastoral are complex assemblages of ecosystem components, each of which benefits the farmers in various ways (Ojeniyi et al., 1980; Bijalwan et al., 2009; Luedeling et al., 2014). Thus, the importance of adopting agroforestry as a land-use system is receiving wider recognition not only in terms of agricultural sustainability but also on issues related to climate change (Chinnamani, 1993; Neupane et al., 2002; Albrecht and Kandji, 2003). The past and present evidence clearly indicates that the adoption of agroforestry, as part of a multifunctional working landscape, can be a viable land-use option that, in addition to alleviating poverty, offers a number of ecosystem services and environmental benefits (Jose, 2009; Buttoud et al., 2013; Alao and Shuaibu, 2013). In particular, the benefits may include but not limited to: First, agroforestry relies on indigenous farming knowledge and selected modern technologies to manage diversities, incorporate biological principles and resources into to farming systems and intensify agriculture production (Van Bael et al., 2008; Chen et al., 2016). Second, it offers the only practical way to restore agricultural lands that have been degraded by conventional agro-economic practices (Kho, 2000; Franzel et al., 2001; Jerneck and Olsson, 2014). Third, it provides environmental benefits: (i) Biodiversity conservation; (ii) Provision of goods and services to society; (iii) Augmentation of the carbon storage in agroecosystems; (iv) Enhancement of soil fertility, and (v) Provision of social and economic well-being to the farmers (Rao et al., 1998; Udawatta et al., 2010; Beetz, 2011).

Another important aspect to note in this study is the assessment of the determinants of agroforestry adoption amongst the smallholder farmers. This is because the determinants of agroforestry adoption by smallholder farmers differ from one region to another. For instance in the Southwest and Northwest parts of Cameroon, the social-economic factors such as the gender of farmer, household family size, level of education, farmer’s experience, membership within farmers’ associations, contact with research and extension workers, security of land tenure, agroecological zone, distance of the village from nearest town, village accessibility and income were the major factors that determined the adoption of agroforestry systems by the smallholder farmers (Nkamleu and Manyong, 2008). This is also in addition to the field characteristics (Bannister and Nair, 2003). Thus understanding the determinants of agroforestry adoption is vital for the uptake of agroforestry practices (Pattanayak and Mercer, 1998; Duguma, 2013).

In determining the adoption of agroforestry systems, it is very important for the farmers to track the occurrences and severity of drought given the fact that their livelihood is dependent on the sustainability of natural resources base (Do Pompeu et al., 2012; Jacobi et al., 2013). In drought assessment, drought indices have proved to meet the requirements of monitoring drought worldwide such as Standardized Precipitation Index (SPI), Palmer Drought Severity Index (PDSI), Crop Moisture Index (CMI), Surface Water Supply Index (SWSI), and Reclamation Drought Index (RDI) among others (Keyantash and Dracup, 2002; Jacobi et al., 2013). These indices have simplified the complex climatic functions and can quantify climatic anomalies as for their severity, duration and frequency (Hayes et al., 1999; Tigkas et al., 2014). From the existing modest and popular indices used for estimation of drought, the Standardised Precipitation Index, known as SPI, seems to win universal applicability (Tsakiris and Vangelis, 2004; Dai, 2011). The Standardised Precipitation Index (SPI) is commonly used to characterise droughts in different compartments of the hydro-meteorological system for any part of the world (Karavitis et al., 2011; Musuuza et al., 2016).

Therefore, assessing the severity and frequency of drought, determinants and environmental benefits of agroforestry adoption as an adaptation response by the smallholder farmers is important in establishing the values farmers attach to agroforestry practices and agricultural production. Besides, many agroforestry studies have only investigated tree-soil interactions (Wezel et al., 2000; Kinama et al., 2005), tree-water interactions (Abebe, 1994; Jones et al., 1998) and tree-crop interactions (Muthuri et al., 2005). However, a few studies (Bessems et al., 2008; Van Asten et al., 2011; Shukla et al., 2014) have documented the occurrences and severities of extreme drought episodes and determinants of agroforestry in tropical semiarid areas for the longer period of uptake such as the last 35 years (Kiptot et al., 2007). In addition, the knowledge, perceptions and attitudes of the potential farmers towards the agroforestry adoption plays a key role, but this has been less studied (Meijer et al., 2014).

This study, therefore, is a significant step forward towards assisting scientists and policymakers comprehend how and why the determinants of agroforestry adoption are important drivers that impact the farmers' adaptation to drought. The study aimed to score the prioritisation of agroforestry adoption in extension programmes tailored towards improving the smallholder farmers' agricultural productivity, especially in drought-prone regions. The specific objectives of this study were to; (i) determine the frequency and severity of drought episodes for the last 35 years (1979-2014) and; (ii) examine the determinants of agroforestry adoption as a drought adaptation response by the smallholder farmers in Nakasongola District, Central Uganda.

## METHODS

### Study area

Nakasongola district is one of the driest districts in Uganda, characterised with prolonged drought episodes, scattered woody biomass plant communities and savannah. The district is located in the north-western part of the central region of Uganda (Roothaert and Magado, 2011). The district has 8 sub-counties namely; Kalungi, Kakooge, Lwampanga, Nabisweera, Wabinyonyi, Nakitoma, Lwabyata, Kalongo and Nakasongola Town Council (Figure 1). The district experiences a bimodal type of rainfall with the first rain season occurring from March/April to June/July and second season occurring from August to October/November of each calendar year. The amount of rainfall received ranges between 500 to 1000 mm per annum. The maximum daytime temperature ranges between 25 to 35°C, while the minimum diurnal range is 18 to 25°C. The soil catena is composed of Buruli and Lwampanga; occurring in both undulating areas and valleys (Mugerwa et al., 2011). In terms of vegetation cover, the most predominant vegetation types occurring in the district include the open deciduous savannah woodlands with short grasses, tropical trees and plantations. For the survival of smallholder farmers, subsistence farming (crop and livestock rearing) is the main source of livelihood engaged by the smallholder farmers in the district. The major types of crops grown include cassava, sweet potatoes and bananas; while the livestock reared include cattle, goats, sheep and poultry (Mugabi et al., 2009). The next sources of livelihood include fishing, sand mining and charcoal burning among others.

### *Meteorological data*

The studied area is one of the areas that are not well monitored in terms of dense meteorological data collection network in Uganda. The existing meteorological dataset had a series of gaps and could not be filled and used for drought assessment. The gaps were attributed to vandalism and subsequent system breakdowns. Hence given this inadequacy, this study downloaded and used the meteorological dataset from the Soil and Water Assessment Tool (SWAT) global weather database (http://globalweather.tamu.edu/). This dataset has been used to assess droughts in the East African region (Gies et al., 2014). The dataset was downloaded from four weather stations; the bounding box extent was: South Latitude 1.1590, North Latitude 1.7273, West Longitude 31.9482, East Longitude 32.6157 that encompassed the study area. The defined period of data collection was from 01/01/1979 to 07/31/2014. This period simplified strong assessment and characterizing drought occurrences and severities. The downloaded climatic parameters included temperature, precipitation, wind, relative humidity and solar; however, it was precipitation that was considered for drought assessment (frequency, duration and severity). The downloaded precipitation dataset was tested for homogeneity and inconsistencies before being used to run drought and wet period's assessment. The preliminary assessment of rainfall trend showed that the study area experienced the same pattern of rainfall distribution but with varying degrees of precipitation amounts over the studied period (Figure 2).

### *Drought assessment*

The Standardised Precipitation Index (SPI) begins with building a frequency distribution from precipitation data at a location for a specified time period (Tigkas et al., 2013). The dataset should have at least a record of 30 years as a prerequisite (Hayes et al., 1999). SPI was developed by McKee et al. (1993). The calculations are based on long-term precipitation record for the desired period. This long-term record is fitted to a probability distribution, which is then transformed into a normal distribution (Hayes et al., 1999). The SPI was developed to detect drought and wet periods at different time scales, an important characteristic that is not accomplished with typical drought indices (Wu et al., 2001). The gamma distribution is defined by its frequency or probability density function:

$$g(x) = \frac{1}{\beta^{a}\Gamma(a)} x^{a-1} e^{-x/\beta}, \text{ for x>0}$$

In which α and *β* are the shape and scale parameters respectively,

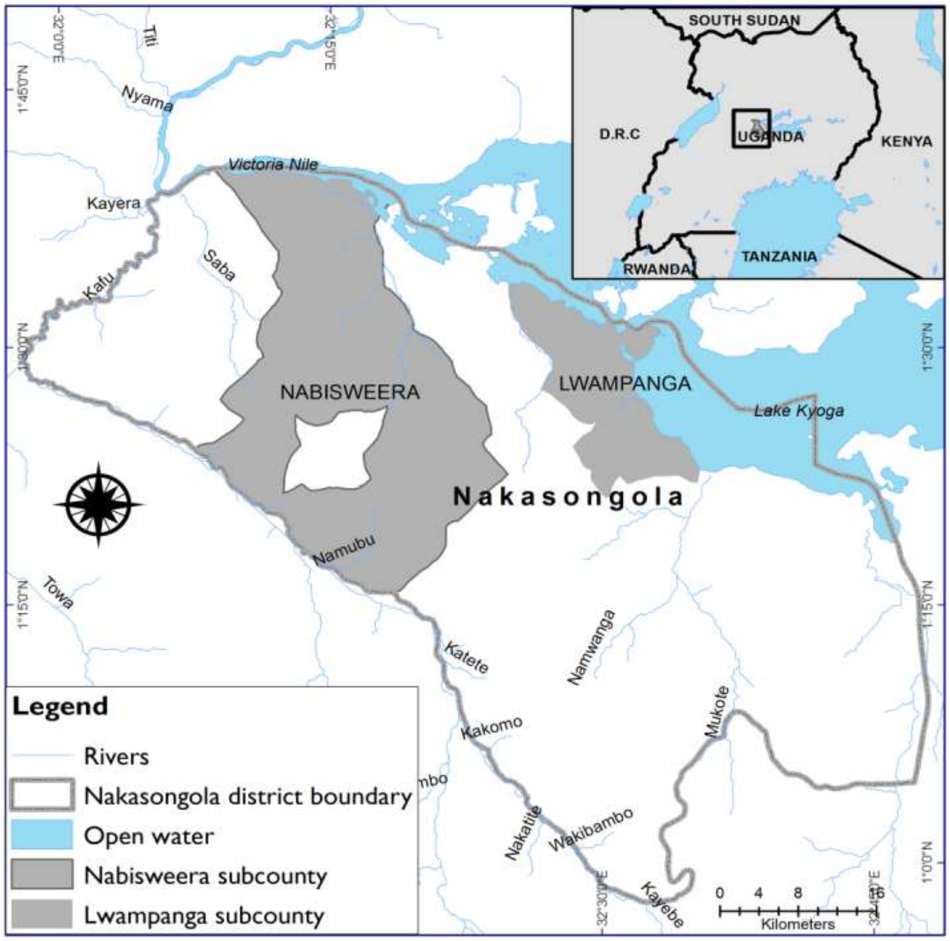


**Figure 1.** Location of study area.

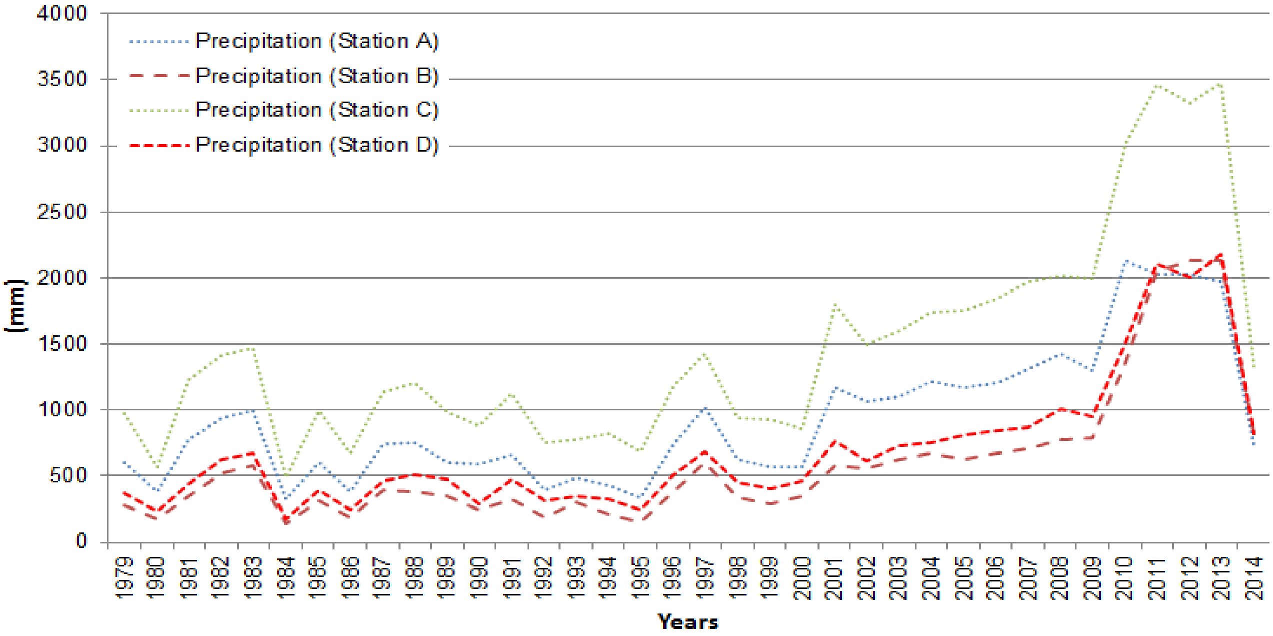


**Figure 2.** Annual precipitation between 1979 and 2014.

**Table 1.** SPI drought class classification (McKee et al., 1993).

| Drought classes | SPI values | Time in category (%) |
|---|---|---|
| Non-drought | SPI ≥ 0 | |
| Near normal | −1 < SPI < 0 | 34.1 |
| Moderate | −1.5 < SPI ≤ −1 | 9.2 |
| Severe | −2 < SPI ≤ −1.5 | 4.4 |
| Extreme | SPI ≤ −2 | 2.3 |

$x$ is the precipitation amount and $\Gamma(\alpha)$ is the gamma function. The maximum likelihood estimations of $\alpha$ and $\beta$ are:

$$a = \frac{1}{4A}\left(1+\sqrt{1+\frac{4A}{3}}\right), \beta = \frac{\bar{x}}{a}, where A = ln(x) - \frac{\sum ln(x)}{n}$$

And $n$ is the number of observations

The resulting parameters are then used to find the cumulative probability of an observed precipitation event for the given month and time scale for the location in question. Since the gamma function is undefined for $x = 0$ and a precipitation distribution may contain zeros, the cumulative probability becomes:

$$H(x) = q + (1-q)G(x)$$

In which $q$ is the probability of zero precipitation and $G(x)$ is the cumulative probability of the incomplete gamma function. If $m$ is the number of zeros in a precipitation time series, then $q$ can be estimated by $m/n$. The cumulative probability $H(x)$, is then transformed to the standard normal random variable $z$ with mean zero and variance of one which is the value of the SPI.

Because the annual rainfall amounts received in Nakasongola District ranges between 500 to 1000 mm per annum (Mugerwa et al., 2011), the rainfall dataset from Station A was selected and used for drought and wet period's detection assessment. The station data lies within the range of measured precipitation data for the study area. The selected timescales for the computation of SPI were: a 3, 6 and 12-month time scales from the 420 monthly precipitation timescales. The shorter timescales of less than 6 months are more useful for detecting agricultural droughts and, while longer ones, may be useful for considering drought impacts on ground water resources (Moreira et al., 2015). The 12-month timescale, as well as larger timescales, identifies anomalous of dry and wet periods of relatively longer duration and relates well with the impacts of drought on the hydrologic regimes and water resources of a region. The frequency and severity of drought were cross-validated with the Ministry of Disaster Preparedness and Management disaster database available for Uganda. The drought computations were grouped into classes as shown in Table 1.

### *Socio-economic data collection*

A cross-sectional design was used to select the respondents. This strategy is easy but does not permit distinction between cause and effect (Mann, 2003; Powell et al., 2013). From the design, a total of 200 respondents were randomly selected from the village members list and visited for interviewing. With simple random sampling procedure, the sample means were unbiased estimators of the population means (Kirk, 2011). The procedures of carrying out simple random sampling were adopted from Kadilar and Cingi (2006). The sample size of selected farmers from each sub-county was 100 respondents. This size gave a moderate representation of the population in the selected sub-counties.

The selected respondents (both women and men) were interviewed using household questionnaires that apprehended information on the practised agroforestry systems, determinants and benefits of agroforestry adoption as a drought adaptation response in the district. Perceptions of farmer's on drought seasonality were also captured in the questionnaire. Interviewing is a more popular means of generating information (Holstein and Gubrium, 2004). The principle respondent was the household head and where the household head was absent, the spouse was interviewed. The respondents were interviewed from their homesteads with the aim to minimise the loss of production time. Field walks were also carried out to evaluate the performance of farmers in their gardens after adopting agroforestry. In addition, two focus group discussions were also conducted from each sub-county comprising of 7 to 10 participants. The focus group discussions were not sex-disaggregated, both men and women attended. The consultations were held at the sub-county headquarters. These discussions helped to assess the determinants of adopted agroforestry practices (Kitzinger, 1994). Furthermore, the key informant interviews were also steered. The interviewed key informants included the District Agricultural Officer, Production Officer and a representative from Nakasongola District Farmer's association. The collected socioeconomic dataset was validated for inconsistencies and coded in SPSS statistical software. The corresponding normality of data facilitated a statistical analysis to test the levels of significance of farmer's determinants of agroforestry adoption. A statistical binary logistic regression was performed in SPSS to examine the significant determinants of farmer's adoption of agroforestry as a response to drought in Nakasongola District. The logistic regression methodology and applications are well explained in detail by Agresti and Agresti (1970).

### *Determinants of agroforestry adoption by the smallholder farmers*

Verifying the farmer's adoption of agroforestry practices requires an in-depth understanding of the household demographic and on-farm and off far characteristics. In addition, the intricate nature of the prevailing farming systems could be appropriately answered by carrying out a logistic regression in examining the determinants of agroforestry adoption. The regression can moderately quantify the relationship between one dependent binary variable and a set of independent variable. A binary logistic regression was implemented to assess the determinants of the farmer's adoption of agroforestry as a drought option using SPSS software and the relationship measured at 5% significance level.

As specified in Agresti and Finlay (1997), the simple logistic regression model has the form:

$$In\left(\frac{\pi}{1-\pi}\right)=\log(odds)=\log Y=\alpha+\beta X \tag{1}$$

When we take the antilog on both sides of Equation 1, we derive the equation to forecast the probability of the occurrence of the outcome of interest as shown in Equation 2:

$$\pi=P(Y)=\frac{e^{\alpha+\beta x}}{1+e^{a+\beta x}} \tag{2}$$

Where 'π' is the probability of the outcome of interest (Y=1); 'α' is the Y intercept (constant of the equation); $\beta$i represents the regression coefficients of the explanatory variables (that is, vector of coefficients to be estimated; e represents a set of predictors, and 'e' is the base of the system of the natural logarithms.

$$\text{The dependent variable Y1i } = \begin{cases} 0 \text{ if household has not adopted agroforestry practices} \\ 1 \text{ if household has adopted agroforestry practices} \end{cases}$$

Taking the log of Equation (2) we have the following logit model for estimating coefficients:

$$In\left(\frac{P(Y=1)}{P(1-P)}\right)=\alpha^{*}+\beta_1^{*}\chi_1+\beta_2{}^{*}\chi_2+....\beta_n{}^{*}\chi_n, \tag{3}$$

Finally, an estimation Equation (3) was undertaken using SPSS statistical software to find the best linear combination of predictors to maximise the likelihood of obtaining the observed outcome frequencies. The predictors of the equation included the level of education, the age of the respondent, household size, environmental policies, land ownership and household income levels.

The interpretations are given in terms of odds ratios and not in terms of marginal effects. Marginal effects are suitable for linear probability models, whereas in the case of binary response models odds ratios give more intuitive meaning (Vittinghoff et al., 2011).

## RESULTS

### Severity and frequency of drought

Results are in conformity that shorter time scales (3-months and 6-months) had higher frequencies of change between the dry and wet periods (Figure 3). The 3-month interval showed higher displacement in the peaks periods of wet years. The increasing time scales presented lower time scales and longer durations. The recorded severe drought years were 1984, 1980, 1986, 1995, 1990, 1999 and 2000 for the assessed period, while the wettest years recorded included 2014, 2012, 2013, 2009 and 2010. The average severe drought return period was 4 years. Figure 4 shows a distinction between the anomalous dry and wet periods of moderately long duration of the drought episodes. The extreme drought events were experienced in the months of July followed by June, whereas the wettest month recorded was November across the studied period (Table 2).

### *Farmer's perceptions on drought seasonality*

Table 3 shows the farmer's perceptions on drought seasonality for the last 10 years. During this period, the studied area experienced two rainy seasons with the first rains occurring during the months of April to June and the second rains received between August and November. The second rains are the lengthiest, while the dry spells were experienced in the months of December to March of each year.

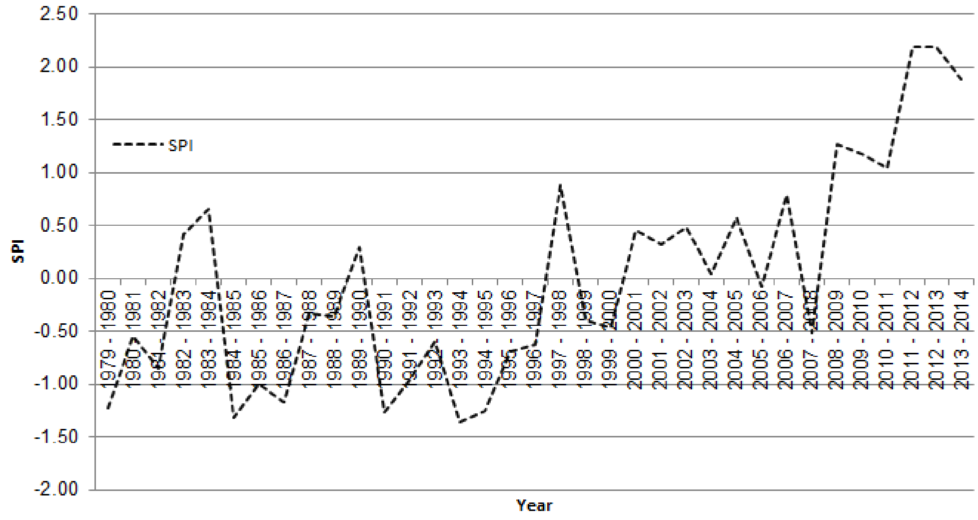
### *Determinants of agroforestry adoption by the smallholder farmers*

Table 4 summarises the results of a logistic regression highlighting the determinants of agroforestry adoption by the farmers as a major drought adaptation response. The study showed that the level of education, age and household income were the most significant determinants of agroforestry adoption ($P<0.05$); unlike the farmer household size, environmental policies and land ownership which did not significantly determine agroforestry adoption. The Omnibus test of the model coefficients was statistically significant while the exponential coefficient Exp($\beta$) and the maximum likelihood estimate of the odds ratio showed that the level of education had a (0.201) negative coefficient which implied that having less education or being uneducated reduced the agroforestry adoption capacity by 0.201 units at 5% level of significance, holding other factors constant. Whereas, the age of the respondents (1.040) posted a positive coefficient which showed that the farmers who were in the 40 to 50 age group had a higher agroforestry adoption capability than those who were below or above the age-group at 5% level of significance, holding other factors constant. Lastly, the farmer income levels (2.103) also posted a positive coefficient which implied that the farmers who had higher levels of income had greater chances/willingness of adopting agroforestry systems as drought adaption responses.

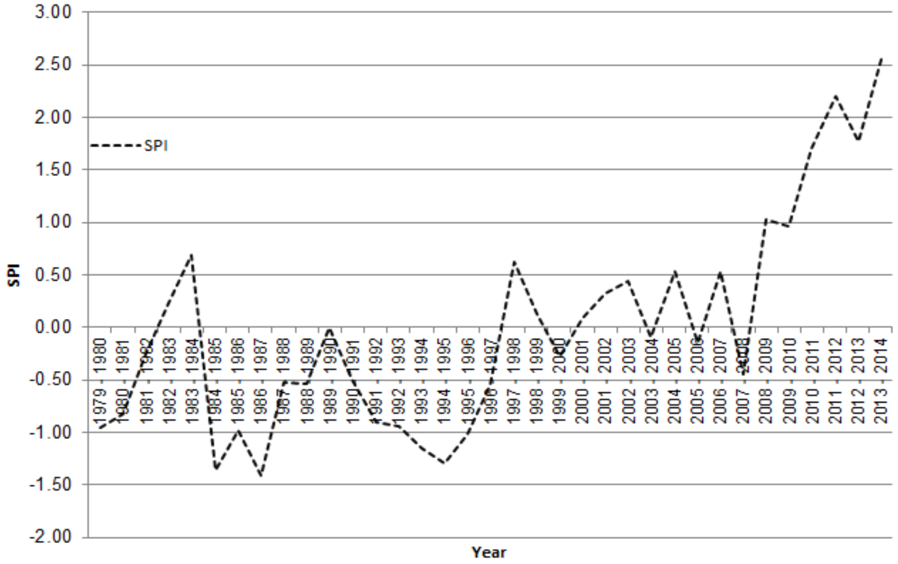
### *Adopted agroforestry systems*

The majority (95%) of interviewed respondents had adopted agroforestry as a drought adaptation response (Figure 4). Agrisilviculture was the utmost adopted agroforestry system undertaken by nearly all the farmers followed by those who practised agrosilvopastoral, silvopastoral and apiculture systems. The pastoral related agroforestry practices were the second most adopted practices implemented by the farmers given the nature of their locality in the semiarid region. Agrisilviculture was the most widely practised system because of its direct benefits it offered the smallholder farmers especially in terms of food and fuelwood provisions. As far as implementation duration was concerned, most of the

3-month SPI (a)



6-month SPI (b)



12-month SPI (c)

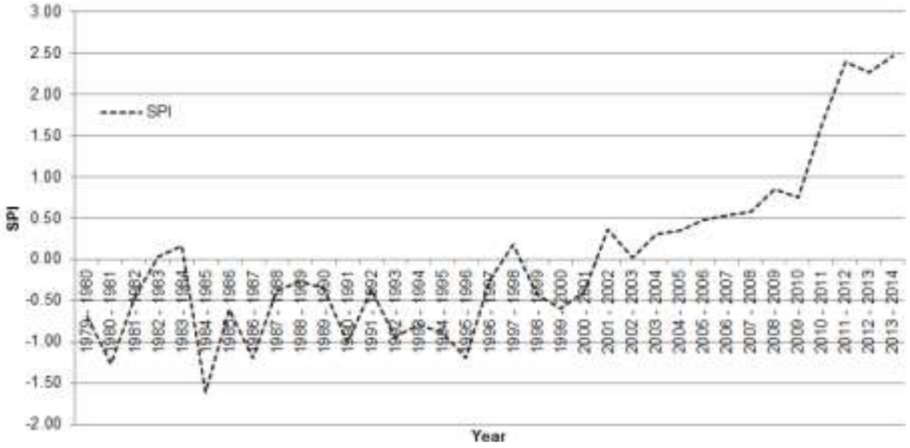


**Figure 3.** SPI values and the major dry and wet episodes recorded in Nakasongola District. Dry and wet periods (a = 3 month SPI; b = 6 month SPI; c = 12 month SPI).

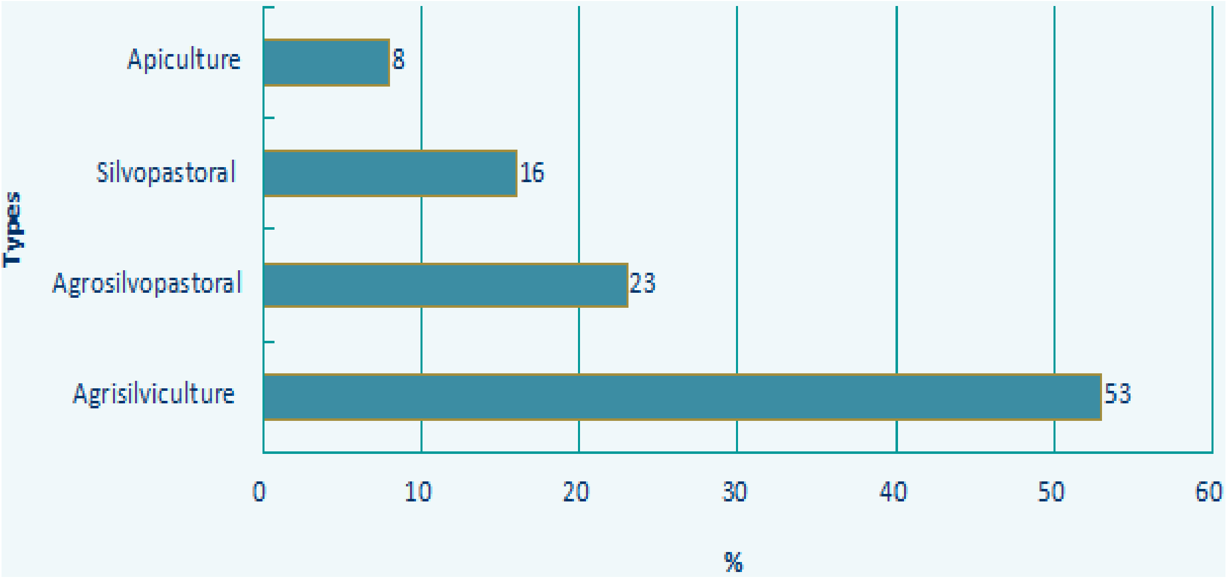


**Figure 4.** Adopted agroforestry systems across the sampled sub-counties.

**Table 2.** Extreme dry and wet periods.

| Occurrences of extreme events | 3-month period | 6-month SPI | 12-month SPI |
|---|---|---|---|
| Extremely drought month | March | March | March |
| Observed year | 1984 | 1986 | 1984 |
| SPI value | -1.3 | -1.4 | -1.6 |
| Extremely wet month | November | November | November |
| Observed year | 2011 | 2013 | 2013 |
| SPI value | 2.3 | 2.6 | 2.9 |

**Table 3.** Seasonal drought seasonality.

| Events (months) | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extremely dry periods | x | | | | | | | | | x | x | x |
| First rains | | xxx | xxx | xxx | | | | | | | | |
| Second rains | | | | | | xxx | xxx | xxx | xxx | | | |
| Onset of dry season | | | | | | | | | xx | xx | Xx | |

farmers (85%) explained to have planted their trees in the period of last five years (2012-2016) followed by those who planted earlier in the last 10 years (15%). Eighty-five percent of the farmers explained that the levels of agroforestry uptake were higher between July and June drought period.

### *Benefits of agroforestry adoption*

Most of the smallholder farmers (80%) adopted agroforestry systems majorly for additional food provision to feed their families and for sale and harvesting of fodder for livestock feeding. These benefits were enjoyed at both on-farm and off-farm (sub-county) levels by the farmers in the studied sub-counties. The farmers benefited from agroforestry adoption through wind protection of their houses and crops from the destructive oscillating winds that were more prominent during both dry and wet seasons. Whereas the other farmers benefited from the systems through the fuel-wood provision, farmland boundary protection and soil fertility enrichment (Table 5). The adopted agroforestry systems were characterised by scattered tree planting, boundary planting, planting of fruit

**Table 4.** Determinants of agroforestry adoption by the farmers.

| Variable in the equation | | | | | | |
|---|---|---|---|---|---|---|
| **Variable names** | ***B*** | **Std.error** | **Wald** | **Df** | **Sig.** | **EXP($\beta$)** |
| Level of education | -1.605 | 0.699 | 5.268 | 1 | 0.022* | .201 |
| Age of respondent | 0.039 | 0.024 | 2.717 | 1 | 0.059* | 1.040 |
| Household size | 0.228 | 0.169 | 1.821 | 1 | 0.177$^{ns}$ | 1.256 |
| Environmental policies | 0.396 | 0.631 | 0.394 | 1 | 0.530$^{ns}$ | 1.486 |
| Land ownership | -0.395 | 0.258 | 2.334 | 1 | 0.127$^{ns}$ | 0.674 |
| Household income levels | 0.743 | 0.446 | 2.777 | 1 | 0.046* | 2.103 |
| Model summary | | | | | | |
| -2Log likelihood | | | | 49.3 | | |
| Cox and Snell R Square | | | | 0.27 | | |
| Nagelkerke R Square | | | | 0.36 | | |
| Hosmer and Lemeshow Test | | | Chi-square | | | |
| | | | 14.2 | 7 | 0.049 | |
| Omnibus tests of model coefficients | | | 14.5 | 6 | 0.024 | |

*Significant at 5% level of significance (P<0.05); $^{ns}$Non significant at 5% level of significance (P>0.05).

**Table 5.** Level of benefits for agroforestry adoption.

| Benefits | Farm level | Sub-county level | Rank (%) |
|---|---|---|---|
| Boundary protection | ■ | | 3 |
| Fuelwood | ■ | | 7 |
| Wind protection | ■ | | 9 |
| Soil fertility enrichment | ■ | | 12 |
| Soil erosion control | ■ | | 15 |
| Food (fruits) | ■ | ■ | 24 |
| Fodder | ■ | ■ | 30 |

trees, tree plantations/woodlots, fodder planting and tree planting carried out in the backyard gardens, distant farmlands and rangelands. The most predominant tree species planted by the farmers to improve their food security status were oranges, mangoes, jackfruit and pawpaws; while for timber and fuel provision, the planted trees included *Pine, Maesopsis eminii, Eucalyptus, Grivellia, and Ficus.* For ecosystem restoration, the planted trees included *Caliandra callothaius, Acacia sp*., among others. A passel of these agroforestry practices was largely adopted at the onset and during the rainy seasons, though their pattern of implementation varied across the sampled respondents reliant on the availability of family labour, income, agro inputs and land tenure among others.

## DISCUSSION

This study indicated that the smallholder farmers were disturbed by the severity and frequency of drought; where the quantities of water continued to reduce over time. In response, the adoption agroforestry offered them both direct and indirect benefits to cope with the effects of drought. This study also indicated that the average severe drought return period was 4 years (1979-2014). This finding was not anticipated given that the district lies in between two large water bodies (Lake Kyoga and Victoria) that have great influence on the local climate of the surrounding areas. The disastrous episodes were more common in the months of March and November. The catastrophic events suffocated the farmers by deteriorating the status of agriculture, water resources and forest ecosystems that are natural resources dependent (Mugabi et al., 2010; Mugisha et al. 2011; Roothaert and Magado, 2011). This condition devastated the farmer's food security status resulting from famine and loss of income (Nabalegwa et al., 2007). The droughts experienced over Africa, are normally triggered by the southward shift of the warmest sea surface temperatures in the Atlantic and warming in the Indian Ocean (Dai, 2011). Locally, the farmers attributed the increases in the frequency and severity of drought to anthropogenic factors such as deforestation, overstocking, wetland degradation and bush burning. Similar observations were also made by Obua et al. (2006) that overgrazing, bush fires and deforestation caused occasional droughts in Nakasongola District. This was further emphasised by Laban et al. (2013) that the distribution of rainfall in eastern and southern Africa had declined by approximately 15% in the last 30 years.

The integration of forestry practices into the implemented farming systems offered the farmers anonymous benefits that helped them cope with drought. In addition to alleviating poverty, agroforestry offered a number of ecosystem services and environmental benefits to the smallholder farmers (Zziwa et al., 2012; Alao and Shuaibu, 2013; Mugerwa, 2015). The proven agroforestry practices implemented by the majority of the farmers included agroagrisilviculture, agrosilvopastoral, silvopastoral and apiculture to enhance their food security status. The adopted agroforestry practices were characterised by scattered trees planting, boundary planting, planting of fruit trees, the establishment of tree plantations and fodder planting. This finding was also reported by Scherr (1992) that farm trees are the main sources of current and future supplies of fuelwood, timber and other important tree products. The adoption rate for the implemented agroforestry systems was 70% for the crop-based systems, while livestock was 30%. The pastoral related agroforestry practices provided higher protein fodder to cattle during the prolonged droughts as was also witnessed by Franzel and Scherr (2002). This observation was in conformity with the findings of Tougiani et al. (2009) who also found out that food security and community resilience to drought enhanced farmer incomes for the farmers located in the semiarid areas.

The social-economic factors were the main determinants of agroforestry adoption by the smallholder farmers (Place and Otsuka, 2002; Bourne et al., 2015). The level of education, age and farmer income levels were the most significant determinants of agroforestry adoption ($P<0.05$) while the household size, environmental policies and land ownership did not. This was also not expected despite the fact that the Ugandan government has increased support in the agricultural sub-sector such as the provision of tree and coffee seedlings and extension services. This finding is also similar to that is made by Buyinza and Mukasa (2007) that young farmers (<50 years) highly adopted agroforestry practices than the older farmers in the cattle corridor. Elsewhere in India, Mahapatra (2002) also found out that the success of agroforestry programme, however, depended on the farmer perceptions, education, the age of the households and resource constraints such as land, labour and capital. Consequently, according to Siriri et al. (2010), the integration of trees on farms may exert complementary or competitive effects on crop yield. However, the constraints faced by the farmers in the adoption of agroforestry practices was a characteristic of smallholder farmers more dependent on the natural resources base for their survival and found in the hard to reach semiarid areas. In this respect, the most frightening constraints included inadequate funds, shortage of planting stock, pests/ parasites and diseases, limited extension services and information. This observation was also similar to that reported by Sonwa et al. (2005) that lack of funds and pests and diseases are one of the major constraints that constrained the farmers from adopting agroforestry practices in semiarid areas. Despite this assessment, further research is vital to determine the effectiveness of the most adopted agroforestry practices.

## Conclusion

The Standardised Precipitation Index performed well in the characterization of drought and wet anomalies as collated with the secondary historical and present weather data records. The index distinctively separated longer durations of drought episodes. On average severe droughts were experienced after every 4 years in Uganda's semi-arid areas. The socio-economic factors were the major determinants of the smallholder farmer's adoption of agroforestry practices in the drylands. Agrisilviculture, agrosilvopastoral, silvopastoral and apiculture were the most outstanding agroforestry systems adopted by the farmers due to their multiple benefits. The adopted agroforestry systems were characterised by scattered tree planting, boundary planting, planting of fruit trees, tree plantations/woodlots, fodder planting and tree planting carried out in the backyard gardens, distant farmlands and rangelands. Thus, the adoption of agroforestry gifted the farmers with environmental benefits such as biodiversity conservation; provision of goods and services improved soil fertility and the social-economic well-being of the farmers.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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