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Smallholder farmers' perceptions of climate change and the roles of trees and agroforestry in climate risk adaptation: evidence from Bohol, Philippines

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Abstract Recent studies have highlighted the importance of trees and agroforestry in climate change adaptation and mitigation. This paper analyzes how farmers, members of their households, and community leaders in the Wahig–Inabanga watershed, Bohol province in the Philippines perceive of climate change, and define and value the roles of trees in coping with climate risks. Focus group discussions revealed that farmers and community leaders had observed changes in rainfall and temperature over the years. They also had positive perceptions of tree roles in coping with climate change, with most timber tree species valued for regulating functions, while non-timber trees were valued as sources of food and income. Statistical analysis of the household survey results was done through linear probability models for both determinants of farmers' perceived changes in climate, and perceived importance of tree roles in coping with climate risks. Perceiving of changes in rainfall was more likely among farmers who had access to electricity, had access to water for irrigation, and derived climate information from government agencies and mass media, and less likely among farmers who were members of farmers' organizations. On the other hand, perceiving of an increase in temperature was more likely among famers who were members of women's organizations and had more off/non-farm sources of income, and less likely among those who derived climate information from government agencies. Meanwhile, marginal effects of the regression on perceived importance of trees in coping with climate change revealed positively significant relationships with the following predictor variables: access to electricity, number of off/non-farm sources of income, having trees planted by household members, observed increase in temperature and decline in yield, and sourcing climate information from government agencies. In contrast, a negatively significant relationship was observed between recognition of the importance of tree roles, and level of education, and deriving income from tree products. In promoting tree-based adaptation, we recommend improving access to necessary inputs and resources, exploring the potentials of farmer-to-farmer extension, using participatory approaches to generate farmer-led solutions based on their experiences of climate change, and initiating government-led extension to farmers backed by non-government partners.

Keywords Roles of trees · Agroforestry · Ecosystem services · Climate change · Adaptation · Philippines

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Introduction

Climate change poses a great threat to agriculture and food security. In recent years, climate change in Southeast Asia has been characterized by increasing temperature, rising sea levels, variable rainfall, and increasing frequency and intensity of extreme weather events (Cruz et al. 2007; Hijioka et al. 2014). Together with population growth, climate change impacts will continue to put pressure on already scarce water resources, and hamper much needed increases in agricultural production to meet the growing demand for food (CCAFS 2014). To ensure food security, the need for more efficient, climate-resilient agricultural production systems is now more pronounced. Unfortunately, in many cases, it is the smallholder farmers—those who rely on agriculture as their main source of livelihood—that are among the most vulnerable and least able to adapt to climate change.

In the Philippines, farmers and fisherfolk have been bearing the brunt of losses due to erratic rainfall, droughts, flooding, and tropical cyclones. Latest statistics show that fishermen and farmers remain the poorest groups in the Philippines (NSCB 2014). Their dependence on natural resources for productivity makes them vulnerable to the effects of climate variability and extremes, and complicates poverty alleviation efforts. Similarly, agricultural and food production systems are highly dependent on ecosystems and the services they provide. Ecosystem services (ESs) are the tangible and intangible benefits that people derive from their environment to attain wellbeing (Millennium Ecosystem Assessment, MEA 2003). Ecosystems are the source of four major types of services (de Groot et al. 2002; MEA 2003). They supply provisioning services—tangible goods that human beings consume or use, such as food, water, timber, and non-timber products. They also provide regulating services, by directly affecting the quantity and quality of soil, air and water, or by shielding communities and households from storms or extreme heat. In addition, ecosystems deliver social and cultural services by contributing to landscape beauty, or by serving as an avenue for ecotourism, or cultural and religious traditions. Supporting services are likewise provided by ecosystems, by sustaining the basic processes that make available the three other types of ES. Together, these services provide some of the most basic inputs that human populations require to attain wellbeing.

Climate change and the risks it brings threaten both ecosystem sustainability and human wellbeing. Research on climate change and its impact in Philippine watersheds has been well documented in recent years. Various studies confirm the negative effects of increasing temperature on production yields of major crops such as rice and corn, quantity and quality of livestock feeds, occurrence of heat stress in animals, and incidence of pests and diseases (Thornton et al. 2008; Comiso et al. 2014). Prolonged droughts—such as the 1997–1998 El Niño—and rising sea surface temperatures likewise resulted in billions of pesos worth of production losses from the Philippine fisheries sector, with aquaculture sustaining bulk of the damages (Guerrero 1999). Consequently, such impacts raise the vulnerability of human settlements to climate change, especially those in increasingly crowded urban poor and marginal rural areas who have less capacity to adapt (Perez et al. 1999; Saldajeno et al. 2012).

"Climate-smart" agriculture presents a way forward, focused on establishing sustainable production systems able to withstand biophysical and socioeconomic shocks while mitigating greenhouse gas emissions, and ensuring food security and overall development (FAO 2010). Research has shown that agroforestry is one such way to mitigate climate change, and at the same time build farm and farmer resilience to climate-related stresses (Verchot et al. 2007). Lasco et al. (2010) assessed the climate change impacts, vulnerability and adaptability of local communities of Pantabangan–Carranglan watershed. The study found that smallholder farmers were indeed highly vulnerable to climate risks. However, their long experience in coping with the vagaries of climate has allowed them to establish many local adaptation strategies—among them, reforestation and agroforestry.

It is estimated that trees can be found on almost half of all agricultural systems in the world, which contribute toward supporting roughly one-third of rural populations (Zomer et al. 2009). Trees serve both regulating and provisioning functions on farms. Agroforestry is a land use approach that aims to maximize the benefits of these functions through the deliberate integration of trees and shrubs with crop and/or livestock production systems (Nair 1993; FAO

2010). Studies have shown that having trees and shrubs on farms builds farm and farmer resilience to biophysical and socioeconomic stresses by supplying food and alternative sources of income, providing feeds for livestock and shade for crops, serving as wind breaks and shelter belts, regulating microclimate, enhancing soil structure and fertility, controlling incidence of pests and diseases, and improving water use efficiency, among others (Lasco et al. 2014a, b; Nguyen et al. 2013; Matocha et al. 2012; Mbow et al. 2014). However, although the overall benefits to farm and farmer resilience has been established, there is very limited empirical data on how trees and agroforestry systems affect the ability of local communities to cope specifically with climate-related risks and hazards. Given the unique attributes of each landscape, many site-specific aspects of the application of agroforestry remain unclear—like ideal crop–tree–livestock combinations, the benefits and/or tradeoffs of these, and the most effective extension approaches (Mbow et al. 2014). Furthermore, studies exploring farmers' attitudes and perceptions regarding climate change, and how they relate to farmers' adaptation behavior have been lacking, especially in the Southeast Asian context (Dang et al. 2014).

Prior to adaptation, individuals and/or groups first recognize changes in the climate, and then choose whether or not they need (or want) to act in response to those changes, and how they intend to do so (Maddison 2007). This study explores the links between farmers' knowledge and perceptions of climate change and the ESs provided by trees, and how these may (or may not) affect their decision-making and behavior in the face of climate risks. More specifically, it examines perceptions of farmers of (1) climate change in Bohol, and (2) the roles played by trees in climate risk adaptation. This study presents findings from community and household-level inquiry regarding ESs provided by trees on farms in Bohol, and seeks to identify individual, household, and farm attributes that may be associated with farmers' ability to perceive roles of trees in coping with climate variability and change. The aim of this study is to provide context-specific evidence to help policymakers and research and development organizations to gain a better understanding of how Filipino smallholder farmers perceive climate change and roles of trees, and the potentials of promoting tree-based agricultural systems to enhance their resilience.

Methods

Profile of the study area

The study sites are two municipalities—Pilar and Danao—in the Wahig–Inabanga watershed on the island province of Bohol, located in the Central Visayas (Region VII) in the Philippines. Bohol is one of the small islands in the Philippines that is vulnerable to climate hazards. Many smallholders farmers live in areas with very limited access to support services from the government. The Wahig–Inabanga watershed is approximately 61,269 ha, encompassing 16 of Bohol's 47 municipalities. It is the largest watershed on the island, and houses the Malinao Dam – the largest dam in the Central Visayas region. Malinao Dam is located in the municipality of Pilar, and supplies the irrigation requirements of roughly 3000 ha of rice land (Blanco 2014). In both Pilar and Danao, majority of land area is low elevation—between 0 and 200 m above sea level (masl)—although some areas are mid (201–400 masl) to high (401–600 masl) elevation (Figs. 1, 2).

Two-thirds of the provincial land area is used for agricultural production, while one-fourth is classified as public domain (i.e., forest/timberland, mangroves, national parks and reserves; PGBh 2006). Pilar and Danao are both fourth class municipalities[1] where—much like majority of the population of Bohol—the main source of income and livelihood is agriculture. The main crops produced in Bohol province include rice, coconut, banana, oil palm, corn, mango, and root crops such as cassava, sweet potato, purple yam and taro. In terms of livestock, the most important sectors (by production volume) are the swine, poultry and cattle industries, respectively (BAS 2014). Dominant soil types in the study sites are Ubay Clay and Ubay Clay Loam (PGBh 2006).

The provincial climate is classified as Type IV—characterized by more or less evenly distributed rainfall throughout the year—making it suitable for rain-fed agriculture. However, recent historical rainfall data from the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) shows an increasing trend from January to March (Q1), with highest rainfall registered in 2011

[1] Municipalities with an average annual income of at least PhP 25 million but not greater than PhP 35 million (http://www.nscb.gov.ph/activestats/psgc/articles/con_income.asp).

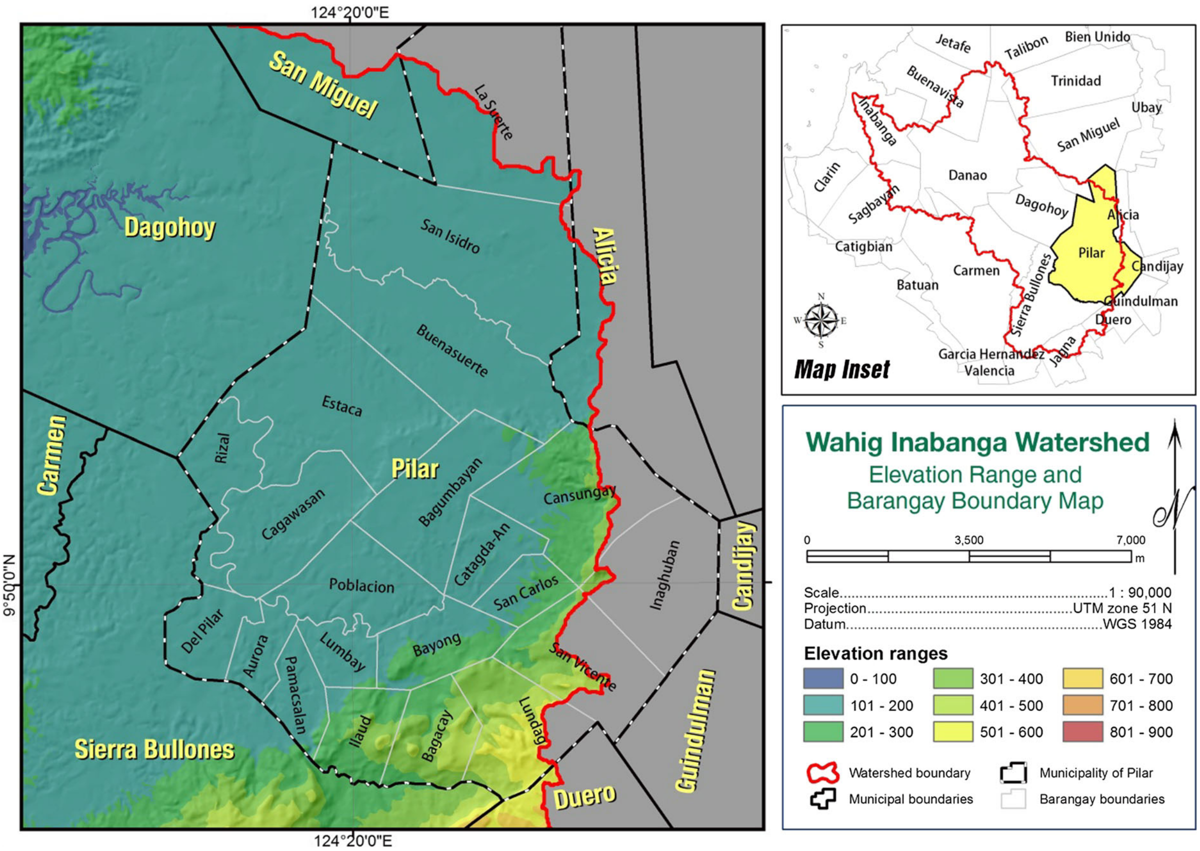

Fig. 1 Elevation range and barangay (village) boundary map of the municipality of Pilar in the Wahig–Inabanga watershed in Bohol, Philippines

and 2008 (Fig. 3). A slightly increasing trend is observed from April to June (Q2) and July to September (Q3), with the most recent highest rainfall for the quarter recorded in 1995. On the other hand, a slightly decreasing trend is apparent from October to December (Q4), with the most recent high rainfall for the quarter recorded in 2000, 2001 and 2003. Also, although rainfall data for 2009 was not available from PAGASA, a report describes rainfall variability in Bohol during this time—with low rainfall from January until March, normal rainfall from May to September, and low rainfall again come December (JICA and IRRI 2012).

Climate projections for Bohol in 2020 anticipate about 1 °C increase in temperature between the months of September and February, and 1.2 °C increase between March and August. Also in 2020, amount of rainfall is expected to decrease by as much as 7.1 % during the summer months (i.e., March, April and May), while increasing between 4.5 and 10 %, depending on the time of the year (PAGASA 2014a). Such changes in climate can be expected to have direct impacts on agricultural productivity and in turn, food security in the province.

Data collection

Community focus groups

Focus group discussions (FGDs) were conducted in selected barangays of the municipalities of Danao and Pilar in August 2012. The local government units assisted the study team in setting selection criteria for FGD participants, which included smallholder farmers, representatives of community-based/farmer organizations, and local government officers. Farmers and representatives of farmer organizations were placed in

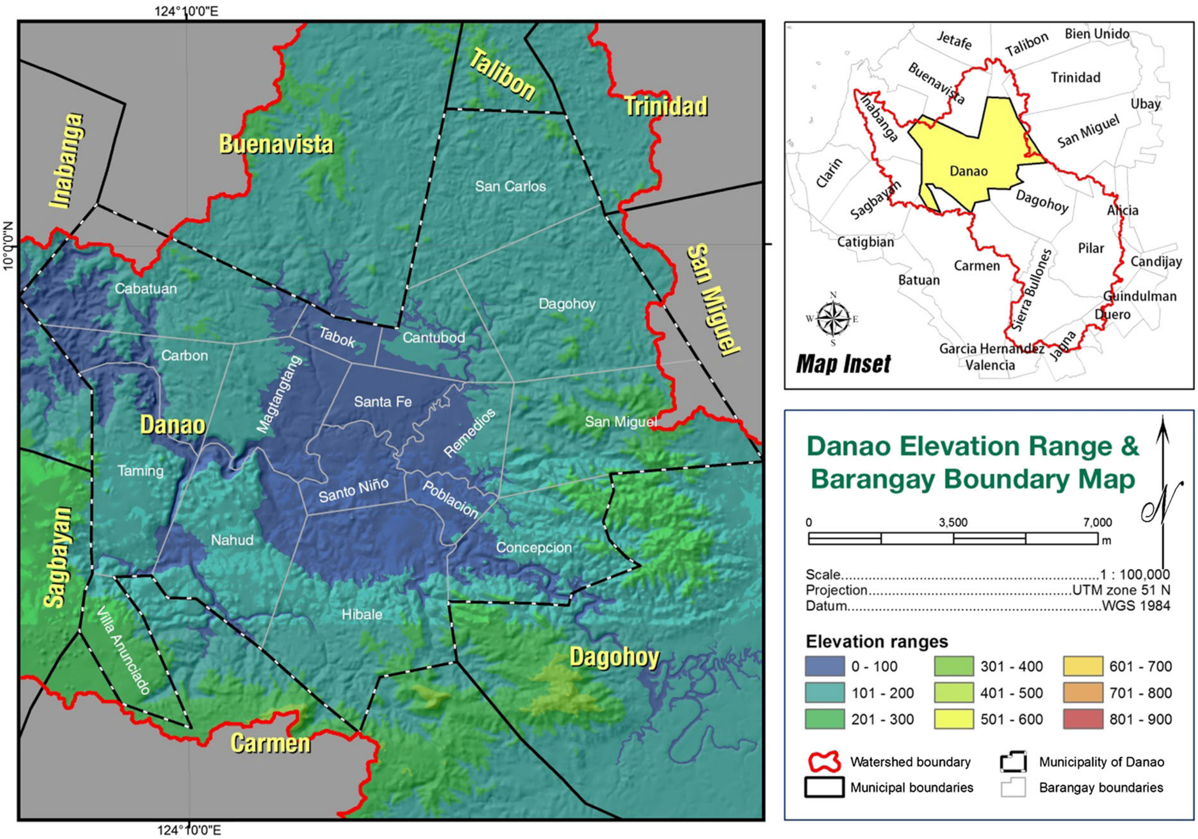

Fig. 2 Elevation range and barangay (village) boundary map of the municipality of Danao in the Wahig–Inabanga watershed in Bohol, Philippines

one focus group, while local government officials and personnel were placed in a separate group. A FGD guide was developed by the study team to provide structure to the exercise, outlining the steps and target outputs. Questions were posed to FGD participants in the local dialect (Boholanon) to ensure better understanding between the facilitators and respondents.

There were three main activities during the FGDs. First, a resource mapping exercise was conducted to characterize the study sites and identify the agricultural products of the area. Second, participants were asked to recall and identify their observed changes in climate and major climate-related events between 1980 and 2012, their impacts on agricultural production, and the corresponding coping mechanisms and adaptation strategies that have been or are being used. The adaptation strategies were then ranked by the participants according to importance. Finally, the third activity featured a brief informative presentation on the functional classifications of ESs based on the MEA framework (2003). Following the presentation, FGD participants enumerated the various uses of trees on- and off-farm, and related these to their functions in helping farmers to adapt to climate risks. The responses regarding the roles of trees were then classified into functional groupings for ESs, and ranked according to importance to the farmers.

Household survey

A household survey was conducted from September to October 2012 to capture more details from farming households regarding their socioeconomic attributes, agricultural activities, observations of climate change, uses of trees, and their perceived roles on farms, especially toward managing climate risks. The survey covered a total of 636 households, representing at least 10 % of the total agricultural population of each of the

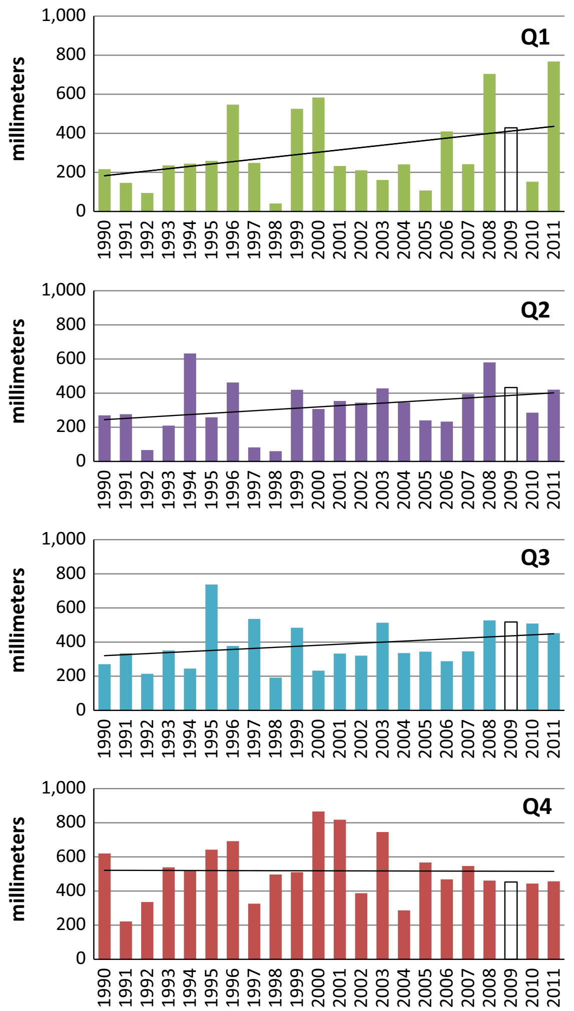

Fig. 3 Annual rainfall (in mm) per quarter, taken in Tagbilaran City, Bohol, Philippines, 1990–2011. *Note* no data for 2009; for the purpose of establishing trend lines, rainfall for 2008 and 2010 were averaged. *Source* http://philfsis.psa.gov.ph/

selected villages. Households were identified through random sampling, but respondents (i.e., household heads or their partners) were interviewed based on availability. Enumerators (who were native speakers of the local dialect) translated each of the questions from English to Boholanon, and recorded answers by translating from Boholanon to English.

Profile of the household survey sample The household survey sample included almost equal proportions of male (52 %) and female (48 %) respondents. The mean age of respondents was 49, with the youngest respondent at 21 years old and the oldest at 88 years old. Only 2 % of the respondents had no formal education, with most of the respondents having attended a few years of elementary school at the least. Average households had roughly five members, most of whom were located in low and mid-elevation areas. One in three households relied purely on on-farm income, while the rest had access to (up to four) other sources of off and non-farm income. Most farmers managed less than 1 ha of total (aggregate) farm area, with most having between one and three farm parcels. Generally, farms were either owned, or under tenancy agreements (Table 1).

There were six distinct agricultural production systems in the study area. Two out of every three farms typically mixed crops, trees and livestock (agrosilvopasture), while others combined only crops and trees (agrisilviculture), or crops and livestock (agropasture) (Nair 1993, 2013). A small percentage of farmers also practiced solely crop culture or forestry. There were four main agricultural products in the area: grains, fruits and vegetables, livestock, and lumber. Majority of agricultural land area was only cultivated with one crop at a time. Rice and corn were the most popular grain crops, while vegetables such as eggplant, string beans and okra were also commonly grown for consumption and income. Roughly four out of five households also reported owning at least one type of livestock. Trees and shrubs were often used to define farm boundaries, while homesteads were lined with fruit-bearing trees for household consumption and income. The most common fruit tree species in the study area included jackfruit, mango, banana, and pomelo. Similarly, 70 % of farmers also had at least one type of timber/plantation tree on or near their farms, the most popular of which were gmelina (*Gmelina arborea*), mahogany (*Swietenia macrophylla*), molave (*Vitex parviflora*), and auri (*Acacia auriculiformis*), with coconut (*Cocos nucifera*) valued for its lumber as well as its fruits.

Data analysis

Community focus groups

Responses for the FGDs on observed changes in climate were tabulated, and then compared with historical records of climate events. Similarly, FGD participants' responses pertaining to roles of trees in coping with climate change were collated and

Table 1 Summary of explanatory (independent) variables

Variables	Description	Mean	Std. dev.	Min.	Max.
Age	Discrete	48.89	14.00	21	88
Gender	Binary (0: male, 1: female)	0.48	0.50	0	1
Level of education*	Ordinal categories	2.60	1.50	0	6
Migrant	Binary (0: no, 1: yes)	0.26	0.44	0	1
Membership in farmers' organization	Binary (0: no, 1: yes)	0.14	0.35	0	1
Membership in women's organization	Binary (0: no, 1: yes)	0.15	0.36	0	1
Household size	Discrete	5.07	2.33	0	14
Derive income from tree products	Binary (0: no, 1: yes)	0.21	0.41	0	1
With access to electricity	Binary (0: no, 1: yes); wealth indicator	0.75	0.44	0	1
Number of sources of off/non-farm income	Discrete	0.79	0.72	0	4
Total farm area (ha)	Continuous	0.94	1.08	0	11.25
With access to water for irrigation	Binary (0: no, 1: yes)	0.43	0.50	0	1
Practicing pure crop culture	Binary (0: no, 1: yes)	0.05	0.21	0	1
On-farm trees planted by household member	Binary (0: no, 1: yes)	0.43	0.50	0	1
Observed change in rainfall	Binary (0: no, 1: yes)	0.93	0.25	0	1
Observed increase in temperature	Binary (0: no, 1: yes)	0.66	0.48	0	1
Observed decline in yield	Binary (0: no, 1: yes)	0.49	0.50	0	1
Climate information from government agencies	Binary (0: no, 1: yes)	0.21	0.41	0	1
Climate information from non-government organizations	Binary (0: no, 1: yes)	0.02	0.15	0	1
Climate information from mass media (TV, radio)	Binary (0: no, 1: yes)	0.28	0.45	0	1
Low elevation (0–200 masl)	Binary (0: no, 1: yes)	0.70	0.46	0	1
Mid elevation (201–400 masl)	Binary (0: no, 1: yes)	0.25	0.43	0	1
Municipality of residence (Danao)	Binary (0: no, 1: yes)	0.42	0.49	0	1

**0* No formal education, *1* attended gradeschool, *2* gradeschool graduate, *3* attended highschool, *4* high school graduate, *5* attended university/college, *6* university/college graduate or vocational diploma holder

summarized, where respondents identified specific tree species, and the most important role of each. Roles of timber and non-timber trees were disaggregated, and also classified according to type of ES (i.e., regulating, provisioning, and cultural and supporting roles).

Household survey

Descriptive statistical analysis was used to summarize and analyze data gathered through the household survey. Regression analysis was then done to explore the factors affecting farmers' perceptions of (1) commonly observed climate change phenomena in Bohol, and (2) importance of trees in coping with such changes. The association of each outcome variable to selected explanatory (independent) variables was tested through three types of binary choice models—linear probability model (LPM), probit regression, and logistic regression—using Stata statistical software version 11.2 (StataCorp 2009). Results of each model were compared. However, since R^2 and pseudo-R^2 values are not always considered the best goodness of fit measures in qualitative choice models such as this (Halcoussis 2005; Verbeek 2008), the models were tested further for percentage of observations predicted correctly. This was done for the outcome (dependent) variables under both (1) and (2), with the results showing that the LPM produced the highest number of observations predicted correctly. As such, the LPM was selected for the purpose of this study.

The outcome variables for perceptions of climate change were (1) whether or not respondents observed changes in rainfall, and (2) whether or not respondents observed an increase in temperature. Affirmative responses were assigned a value of "1", and the rest, assigned with "0". Meanwhile, the outcome variable for tree roles was indicated by respondents' perception (recognition) of the importance of trees in enhancing their coping mechanisms to climate change, validated through their identification of specific roles played by trees. More specifically, respondents were asked, (1) "Do you have trees in your own farm" (yes or no), (2) "Do trees on-farm play important roles in enhancing your coping mechanisms to the impacts of climate change?" (yes or no), and (3) "If yes, what roles do trees play in enhancing your coping mechanisms to changes in climate?". Respondents who satisfied Question 1 (i.e., had trees on their farms), answered "yes" to Question 2, and were able to enumerate at least one tree role in coping with changes in climate in Question 3 were assigned a value of "1", while all the rest were assigned with "0".

Age Age of the farmer/respondent is sometimes taken as a proxy for farming experience (Deressa et al. 2009). Studies have found that farmers with more experience are significantly more likely to perceive changes in climate, such as rain variability and increase in temperature (Bryan et al. 2013; Maddison 2007), though the opposite was also observed in other studies (Gbetibouo 2009). Meanwhile, others found that age of household head was not a significant predictor of people's perception of ESs, including those provided by trees and forests (Muhamad et al. 2014). In some cases, farmers with more years of farming experience were found more likely to adapt to climate change—including adaptation by planting trees (Deressa et al. 2009; Gbetibouo 2009; Apata et al. 2009)—while in other cases, it had no effect (Bryan et al. 2013).

Gender and education Prior studies found that gender and education were not significant predictors of perception of climate change (Gbetibouo 2009; Bryan et al. 2013). Muhamad et al. (2014) observed that respondents with no formal education were significantly less likely to perceive of regulating, cultural and supporting ESs provided by trees and forests. In terms of adaptation to climate change, Deressa et al. (2009) found that gender of household head, and educational attainment of the respondent were positive predictors, including adaptation specifically by planting trees. This study also argued that male-headed households were 10 % more likely than female-headed households to plant trees to adapt to climate change, although other studies found otherwise (Deressa et al. 2009). However, a similar study did not find any significant association between gender and education of the household head, and adaptation (Bryan et al. 2013). Existing literature appears to indicate that even when individual attributes (i.e., age, gender, and level of education) of farmers/respondents do not predict perception/recognition of climate change and ESs, they could still be important determinants of farmer behavior and action (i.e., through adaptation).

Social groups In some contexts, farmers who were members of local organizations were found to be more likely to plant trees to adapt to climate change (Bryan et al. 2013), while in other contexts, local organizations (such as cooperatives) were found to be avenues more for exchanging information pertaining to crop production and marketing, rather than for sharing information about climate change (Frank et al. 2011). On the other hand, a study in Pakistan found that opinions of farmers' family members, landlords/tenants, other farmers, and village leaders were important considerations in deciding whether or not to plant trees on their farms (Zubair and Garforth 2006). Membership in local organizations (i.e., farmers' and women's organizations) was thus considered an important variable for this study. The study also tested whether or not personal identification with the agent who planted trees on farm would be associated with how farmers perceive the roles of trees in coping with climate change.

Household size The effect of household size on uptake of climate change adaptation options is indistinct across studies. Some studies suggest that responding to climate change and its accompanying medium to long term risks can be difficult to prioritize alongside other basic needs and goals (Lyle 2015; Jerneck and Olsson 2013). In many cases, more household members means more needs and goals to be met, especially in households with fewer productive than unproductive members. The negative relationship between household size and likelihood of climate change adaptation can also be found in other research (Tizale 2007; Apata et al. 2009; Bryan et al. 2013). On the contrary, other studies (Hassan and Nhemachena

2008; Croppenstedt et al. 2003; Deressa et al. 2009, 2011; Bryan et al. 2013; Alauddin and Sarker 2014) contend that households with more members in fact had greater capacity than households with fewer members to adapt to climate change, primarily because larger households had greater human capital—a key asset toward reducing vulnerability through diversification of income and livelihood (Chambers 2006). These mixed findings suggest that the effect of household size on farmers' perception of the roles of trees in coping with climate change is at best, still equivocal and context-specific.

Location Location attributes—such as elevation, village, municipality, or country of residence—sometimes predict perceptions of climate change, and adaptation. Maddison (2007) modeled African farmers' perceptions of climate change, and found that farmers living in Burkina Faso, Egypt, Ethiopia, South Africa and Niger were significantly more likely to perceive of changes in temperature, while farmers living in Ghana, Niger, Senegal and Ethiopia were also significantly more likely to recognize a change in rainfall patterns. A study by Muhamad et al. (2014) in high elevation forest-agricultural areas in Indonesia established that farmers living in close proximity to forests were more likely to perceive of ESs, including those provided by trees. Conversely, in the study by Deressa et al. (2009), location in lowland areas was negatively associated with adaptation to climate change through tree-planting.

Wealth and income Maddison (2007) observed that subsistence farmers were significantly more likely to observe changes in temperature and rainfall than farmers belonging to higher income brackets, possibly owed to their greater dependence on natural resources for livelihood. Studies have also explored the links between wealth (and other related indicators) and likelihood of adapting to climate change, since adaptation to climate change—including tree-based adaptation strategies—often requires ample financial capital (Bryan et al. 2013; Deressa et al. 2011; Jerneck and Olsson 2013; Nguyen et al. 2013; Knowler and Bradshaw 2007). In this study, proxy variables for wealth and income included access to electricity, number of sources of off/non-farm income, and deriving income from tree products.

Farm attributes In the study by Gbetibouo (2009), no significant relationship was found between perception of climate change and farm size. However, area of agricultural lands owned has been positively associated with perception of ESs (Muhamad et al. 2014). Likewise, farm area has been positively associated with adoption of certain adaptation strategies (Alauddin and Sarker 2014; Gbetibouo 2009; Apata et al. 2009), including tree-planting (Bryan et al. 2013), although others find the contrary (see Hassan and Nhemachena 2008). Farmers with access to water for irrigation were less likely to perceive of climate change in the study by Gbetibouo (2009), but did not have any significant effect on such perceptions and on adaptation in the study by Bryan et al. (2013). Type of agricultural production system (i.e., number and/or type of farm components) has been factored into models examining perception of climate change (Bryan et al. 2013; Deressa et al. 2009) and ESs (Muhamad et al. 2014). In this study, agricultural production system was represented by whether or not the farmers were practicing purely crop culture.

Observed climate change and impacts Weber (2010) discusses how recent personal experience of climate-related change makes individuals more conscious of risks, and more willing to adopt potential adaptive responses (see also Mertz et al. 2009; Maddison 2007; Weber 2006). However, Gbetibouo (2009) cautions that it is important to consider that some farmers lump observed short-term changes (weather) with the longer-term ones (climate) and as such, reported observations may not necessarily be reflective of actual climate change (see also Weber 2010; Bryan et al. 2009). For this reason, respondents' perceptions/observations of climate change were gathered, but results of the FGDs and historical climate data were used to validate the responses.

Sources of climate information Dang et al. (2014) assert that farmers' climate change perceptions and attitudes are influenced by their access to information. Meanwhile, several studies have also highlighted the importance of access to extension (Di Falco et al. 2011; Truelove et al. 2015; Gbetibouo 2009) and climate information (Di Falco et al. 2011; Roco et al. 2014; Tizale 2007) as predictors of adoption of climate adaptation measures. Gbetibouo (2009) found that farmers with access to extension services are more likely to adapt to climate change because aside from being a source of technical support, such services also provide information on climate change and its impacts. In addition, other studies have shown that farmers become less likely to adopt certain adaptation practices if they feel that the climate information (e.g., seasonal forecasts) they receive is unreliable (Alauddin and Sarker 2014; Gandure et al. 2013). For this reason, respondents' sources of climate information were factored into analysis as possible influences on perception of climate change, and of the roles of trees in coping with climate change.

Results and discussion

Perceptions of climate change in Bohol

Farmers and members of the community must first recognize that climate change is occurring before they can decide whether or not (and how) to adapt to it. Participants recalled climate phenomena such as the El Niño Southern Oscillation (El Niño and La Niña), tropical cyclones (especially typhoons), and changes in the onset of wet and dry seasons during specific time periods (Table 2). Placed alongside historical records of climate events from PAGASA and the National Oceanic and Atmospheric Administration (NOAA)'s Climate Prediction Center (NOAA 2015), results of FGDs show that farmers and local stakeholders were able to accurately recall a number of the major climate events that affected the study area (and the rest of the country), together with their approximate year/s of occurrence.

In terms of rice production, Bohol is considered among most vulnerable provinces to El Niño in the Philippines (de Vera 2014). El Niño events—brought about by warming of the Eastern and Central Pacific Ocean—have been linked to the occurrence of major droughts in the Philippines, which have been recurring in shorter intervals in recent years (Tejada et al. ND). Farmers recalled five occurrences of El Niño in the 20 years preceding and during the year of data collection, although there were actually seven recorded El Niño occurrences based on PAGASA and NOAA's records. Farmers' reports of "El Niño" in 2005 was depicted in local dailies—drought in

Table 2 Three-decade timeline of farmers' recalled climate events in Wahig–Inabanga watershed, Bohol, Philippines versus PAGASA's recorded historical climate events

Year	1980-1985	1986-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2012
Respondents' recalled climate events	**El Niño (1982)**	Early wet season (1988)	**El Niño (1993)**	**La Niña (1996)**	**La Niña (2000)**	**La Niña (2006)**	El Niño (2012)
	Typhoon Ike/*Nitang* (1984)	**La Niña (1989)**	Typhoon	**El Niño (1996, 1998)**	**El Niño** Typhoon	Early wet season	Early dry season (2012)
Historical climate events	**La Niña (1984-1985)**	**La Niña (1988-1989)**	**El Niño (1991-1992, 1994-1995)**	**La Niña (1995-1996, late 1998-2000)**	**La Niña (2000-early 2001)**	El Niño (2006-2007, 2009-2010)	Prolonged wet season (Southwest monsoon or *Habagat*), Luzon
	El Niño (1982-1983) **Typhoon Ike/*Nitang* (1984)**	El Niño (1986-1988)		**El Niño (1997-early 1998)**	**El Niño (2004-2005)**	**La Niña (2007-2008)**	La Niña (2010-early 2011, late 2011-2012)

Note: Items in bold represent answers from respondents that matched a climate event in historical climate records

Sources Farmers' recalled events from focus group discussions; historical climate events from the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) and the National Oceanic and Atmospheric Administration (http://www.cpc.noaa.gov)

Bohol in 2005 resulted in millions of Philippine pesos worth of losses to the rice and corn production sectors (Mosqueda 2005). Meanwhile, another drought prompted cloud-seeding efforts to prevent agricultural losses again in 2012 (Valencia 2012). However, it is worth noting that FGD participants associated a recollection of drought in 2012 with El Niño, even though historical records of NOAA showed no indication of El Niño occurrence in 2012. From this we gather that farmers associate drought with the term "El Niño", even when the drought in question may not be resulting from the El Niño Southern Oscillation.

To supplement FGD findings, household survey respondents were also asked regarding their observations and/or experiences of climate change since they started farming. More specifically, they were asked (1) If they had observed a significant change in climate since they started farming (1: yes, 0: no), and (2) If yes, what their specific climate observations were. Results showed that the most commonly perceived changes in climate were related to rainfall (i.e., having more rainfall than expected, having less rainfall than expected), and increase in temperature (Fig. 4). In addition, almost half of our household survey respondents reported having observed increased frequency of typhoons. Indeed, relative to two prior 30-year averages (i.e., 1951–1980 and 1961–1990), there was a slight increase in number of typhoons that passed over the Visayas between 1971 and 2000 (PAGASA 2014b). While it was previously uncommon for Bohol—along with the rest of the Visayas and Mindanao regions—to be affected by typhoons, the Climate Change Commission has noted that the Philippine "typhoon belt" has shifted from Bicol region and northeast Luzon, to the Visayas and portions of southern Luzon (Fernandez et al. 2014), with more typhoons passing through these areas in recent years.

A LPM was used to further explore the determinants of farmers' perceptions of climate change. Results of the regression showed that respondents with access to electricity (an indicator for wealth) were more likely to perceive of both changes in rainfall, and increase in temperature (Table 3) . More specifically, perception of changes in rainfall was more likely among respondents who had access to water for irrigation, received climate information from government agencies and through mass media (such as TV and radio). Conversely, perception of changes in rainfall was less likely among respondents who were members of farmers' organizations. On the other hand, members of women's organizations were more likely to perceive an increase in temperature, with likelihood of perception also increasing as number of off/non-farm sources of income went up. Meanwhile, perceiving temperature increase was less likely among farmers who obtained their climate information from government agencies.

Perceptions of tree roles in climate risk adaptation

The FGDs established that farmers in Bohol valued trees for their regulating services, such as their ability to provide shade, act as fencing or riprap, and maintain soil moisture and structure (Table 4). Provisioning services of trees were also recognized, including provision of food, timber wood, additional forage for livestock, and mulch. Non-timber species (usually fruit-bearing trees) were recognized for both their regulating and provisioning services, but were deemed more important in sustaining the latter, mostly as a source of food or income from the sale of non-timber tree products. Coconut was an exception, as it was recognized as having regulating, provisioning and

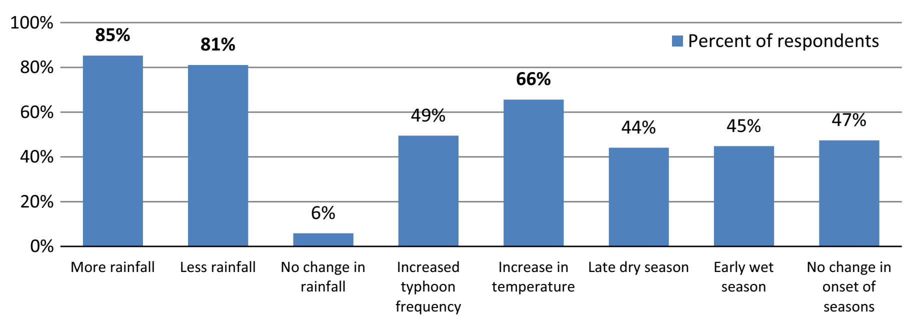

Fig. 4 Farmers' perceived changes in climate since they started farming, Bohol, Philippines, 2012 (N = 636)

Table 3 Determinants of farmers' perception of changes in rainfall and increase in temperature, Bohol, Philippines using a linear probability model

Variables	Changes in rainfall		Increase in temperature	
	Coefficients	Standard error	Coefficients	Standard error
Age	0.0008	0.0008	−0.0007	0.0014
Gender (female)	0.035	0.0227	0.0012	0.0421
Level of education	0.0033	0.0070	0.0101	0.0130
Migrant	−0.0147	0.0225	0.0553	0.0417
Membership in farmers' organization	**−0.0995*****	0.0295	0.0511	0.0548
Membership in women's organization	−0.039	0.0310	**0.1561*****	0.0576
Household size	0.0004	0.0044	−0.012	0.0082
Access to electricity	**0.0678*****	0.0242	**0.2231*****	0.0449
Number of off/non-farm sources of income	0.017	0.0145	**0.0766*****	0.0268
Total farm area (ha)	0.0082	0.0097	0.0093	0.0179
With access to water for irrigation	**0.0472****	0.0212	−0.0458	0.0393
Practicing pure crop culture	−0.043	0.0474	−0.0622	0.0879
Climate information from government agencies	**0.0624****	0.0257	**−0.1828*****	0.0476
Climate information from NGOs	0.0943	0.0679	0.1557	0.1259
Climate information from mass media	0.0416*	0.0231	0.0096	0.0429
Low elevation (0–200 masl, base high elevation)	−0.0334	0.0471	0.0454	0.0874
Mid elevation (201–400 masl, base high elevation)	−0.0083	0.0486	0.0088	0.0901
Municipality of residence (Danao, base Pilar)	0.0125	0.0235	0.0688	0.0437
Constant	**0.7913*****	0.0715	**0.4387*****	0.1325
R^2	0.0735		0.1082	
N	636		636	
Percent of observations predicted correctly	93.2		81.6	

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

cultural significance. Aside from providing shade, timber, and non-timber products, coconut palms were also common decorations during *fiestas* and community gatherings, while coconut trees were used for coconut-climbing contests. On the other hand, timber tree species were recognized for providing regulating, provisioning, and cultural and supporting services, but were valued mainly for their regulation functions—such as provision of shade, and maintenance of soil structure and moisture. The use of timber products was more common in Pilar. Some locals believed that spirits inhabit certain timber species (particularly acacia), and as such, opted not to cut down the trees for timber for fear of offending the spirits. Instead, farmers reported using such trees for shade, as a source of additional forage for livestock, or leaves for mulching and organic fertilizer.

Determinants of farmers' perceptions of tree roles

Through a LPM, responses from a subset (n = 576) of the household survey sample (N = 636) were used to identify determinants of farmers' recognition of the value of tree roles in coping with climate change. Analysis included only responses from farmers who declared that they had trees on their farms. Marginal effects of the LPM revealed positive significant relationships between perception of trees as important in coping with climate change and the following predictor variables: having access to electricity (as a wealth indicator), number of off- and non-farm sources of income, having trees planted by a household member, observed increase in temperature, observed decline in yield, and deriving climate information from government sources (Table 5).

Table 4 Tree species and roles enumerated by stakeholders of Wahig–Inabanga watershed, Bohol, Philippines during focus group discussions, 2012

Local names (scientific names)	Roles of trees			Most important role		
	Regulating	Provisioning	Cultural and supporting	Regulating	Provisioning	Cultural and supporting
Non-timber species						
Mango (*Mangifer indica*)	•	•			•	
Coconut (*Cocos nucifera*)	•	•	•		•	
Rambutan (*Nephelium lappaceum*)	•	•			•	
Caimito (*Chrysophyllum cainito*)	•	•			•	
Coffee (*Coffea* sp.)	•	•			•	
Jackfruit (*Artocarpus heterophyllus*)	•	•			•	
Timber species						
Balete (*Ficus* sp.)	•	•	•	•		
Talisay (*Terminalia catappa*)	•	•	•	•		
Acacia (*Acacia auriculiformis*, *Acacia mangium*, *Samanea saman*)	•	•	•	•		•
Mahogany (*Swietenia macrophylla*)	•	•	•	•		
Narra (*Pterocarpus indicus*)	•	•	•	•		

Source focus group discussions

Meanwhile, negatively significant associations were found with level of education, and deriving income from tree products.

Level of education

Perceiving the importance of trees in coping with climate change was less likely among farmers with higher levels of education, although this was only at 10 % level of significance. These findings were consistent with those of a recent study in West Java, Indonesia, where respondents who had higher educational attainment tended to recognize fewer ecosystem (especially regulating, supporting and cultural) services than respondents with less and no formal education (Muhamad et al. 2014). Martín-López et al. (2012) had similar results, where respondents with lower educational attainment were found more perceptive of provisioning services of ecosystems than those who had more years of formal education. A look at descriptive statistics reveals that 64 % of farmers had either no formal or only basic education, and yet respondents belonging to this category represented majority of those who recognized the importance of trees in coping with climate change (Table 6).

Wealth and sources of income

Results of regression analysis show that farmers' perceptions regarding the importance trees in coping with climate change were significantly influenced by the farming household's available resources. Access to electricity (used here as an indicator of wealth), and number of off- and non-farm sources of income (e.g., employment as laborers in other farms, contributions of family members employed non-farm industries, remittances of relatives working abroad) both emerged as significant predictors of perception of trees as important in coping with climate change (at 1 and 5 % level of significance, respectively). This tells us that farmers with more stable financial capital are more likely to value on-farm trees in reducing their vulnerability to climate risks. The same was true in prior studies which found significantly positive association between adaptation to climate change by planting trees, wealth (Bryan et al. 2013) and having access to off/non-farm sources of income (Deressa et al. 2009).

Here, indicators of wealth and income represent the farming household's agency—the capacity (or means) to adapt along with the intent (Giddens 1984). A negatively significant relationship was observed

Table 5 Determinants of farmers' perceptions of tree roles in coping with the impacts of climate change using a linear probability model, marginal effects

Variables	Coefficients	Standard error
Age	−0.0006	0.0013
Gender (female)	0.027	0.0345
Level of education	**−0.0205***	0.0120
Household size	0.0024	0.0075
Derive income from tree products	**−0.0686***	0.0404
With access to electricity	**0.1853*****	0.0435
Number of sources of off/non-farm income	**0.0561****	0.0250
Total farm area (ha)	0.0067	0.0166
With access to water for irrigation	0.0149	0.0364
Trees planted by household member	**0.2835*****	0.0352
Observed change in rainfall	0.0553	0.0722
Observed increase in temperature	**0.0833****	0.0370
Observed decline in yield	**0.0689****	0.0346
Climate information from government agencies	**0.2379*****	0.0440
Climate information from non-government organizations	0.1581	0.1104
Climate information from mass media (TV, radio)	0.0498	0.0394
Low elevation (0–200 masl, base high elevation)	−0.1006	0.0771
Mid elevation (201–400 masl, base high elevation)	0.0627	0.0800
Municipality of residence (Danao, base Pilar)	−0.062	0.0398
R^2	0.2670	
n	576	
Percent of observations predicted correctly	80.4	

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table 6 Farmers' household survey responses regarding the importance of trees in enhancing coping mechanisms to climate change, by level of education, Bohol, Philippines (n = 576)

Level of education	**Description**	***Do trees on-farm play important roles in enhancing your coping mechanisms to the impacts of climate change?***				
		No	**%**	**Yes**	**%**	**Total**
0 – No formal education	No formal education	1	0%	9	2%	10
1 – Attended grade school	Basic education	53	9%	103	18%	156
2 – Grade school graduate		42	7%	110	19%	152
3 – Attended high school		24	4%	79	14%	103
4 – High school graduate		25	4%	65	11%	90
5 – Attended university/college	Higher education	13	2%	12	2%	25
6 – University/college graduate or vocational diploma holder		13	2%	27	5%	40
	Total	171	30%	405	70%	**576**

between perceiving trees as important in coping with climate change, and deriving income from tree products, but only at 10 % level of significance. This suggests that farmers who sold their tree products were less likely to recognize the value of trees in coping with climate change, but this represents only a small group within the study sample. Indeed, more than half of the respondents (313 out of 576) said that they did not derive any income from tree products, but saw on-farm trees as important in coping with the impacts of climate change (Table 7). Recalling the FGDs, coconut was the main species valued largely as a source of income, but also for household consumption purposes. However, household survey results revealed that only a small proportion (13 %) of farmers derived income from coconut, and fewer still from other tree species. Non-timber (fruit) trees such as jackfruit, mango, rambutan, caimito and coffee were also identified as being most important for their provisioning roles, but household survey results revealed that such trees and shrubs were more for household consumption rather than income. This implies that provisioning roles of trees are valued for coping with climate change even if tree products supply household needs but do not yield financial gains.

The poor reduce their vulnerability to risks by expanding their range of assets, including diversification of sources of income and livelihood (Chambers 2006). Bryan et al. (2013) found that planting trees—considered as a capital intensive climate adaptation measure—was more likely to be done by wealthier farming households. However, their descriptive statistics showed that almost 40 % of their respondents expressed the desire to invest in agroforestry, but were unable to do so due to lack of resources (i.e., investment capital, farm inputs, water supply, land) and information (see also Acosta-Michlik and Espaldon 2008). Similarly, Jerneck and Olsson (2013) also found that investment in trees and nurseries was more common among food secure, opportunity-seeking farmers compared to food insecure, risk averse farmers. In spite of this, they highlighted that although subsistence farmers recognize and appreciate the various benefits provided by trees, other priorities (such as food and health) are likely to prevent them from investing in agroforestry (Jerneck and Olsson 2013). It appears that even when tree roles are deemed important and there is intent to adapt, resource limitations still act as major barriers to farmers' use of trees in coping with climate change.

Aside from resource considerations, productivity concerns can also act as barriers to the integration of trees on farms. A study by Cerdán et al. (2012) of coffee farmers in Costa Rica found that in making farm management decisions, maximizing productivity of cash crops took precedence over considerations regarding supply of ESs. Anecdotal reports from household survey respondents revealed that farmers were concerned that trees would have unfavorable effects on the soil, or impair the growth and development of their cash crops. Ironically, the productivity of crops is ultimately contingent on the farmers' capacity to adapt to the changing climate, which is likewise dependent on their ability to make the most of the natural and social assets available to them (Nguyen et al. 2013)—including ESs provided by trees. While factoring climate change adaptation into farm management decisions—with suitable combinations of crops, trees and livestock—could prevent longer-term productivity losses, short-term productivity maximization may be a more immediate concern of smallholder farmers, especially for those living on subsistence.

Agent who planted trees

Respondents were asked whether or not they had trees on their farms, and if so, who planted them. Although the reason for planting trees was not addressed, having trees that were planted by household members was another significant predictor for perceiving tree roles as important in coping with climate change (at 1 %

Table 7 Farmers' household survey responses regarding the importance of trees in enhancing coping mechanisms to climate change, according to whether or not they derive income from tree products, Bohol, Philippines (n = 576)

Derive income from tree products?	Do trees on-farm play important roles in enhancing your coping mechanisms to the impacts of climate change?				
	No	%	Yes	%	Total
No	130	23	313	54	443
Yes	41	7	92	16	133
Total	171	30	405	70	576

level of significance). Compared to farmers who had only naturally-occurring trees on their farms, farmers whose household members deliberately planted trees on their farm (and/or residence) were significantly more likely to recognize the contribution of trees toward their coping mechanisms to the changing climate. This can be related to the findings of Frank et al. (2011), who highlight that farmers' reception of new information or knowledge (which can also extend to technology) is influenced partly by whether or not the farmer can identify with the proponent, and whether or not that proponent is perceived to be credible.

Certainly, investing in trees requires access to inputs and a long-term outlook, as benefits do not materialize until several years after the initial capital outlay (Bryan et al. 2013; Nguyen et al. 2013). As such, farmers' perceptions of tree roles in coping with climate risks, and the influence of whether or not the trees were planted by household members were also examined in reference to the household's available resources. Cross tabulation of access to electricity (a), the number of respondents who had trees planted by household members (b), and perception of tree roles as important in coping with climate change (c), revealed that roughly one-third of respondents answered affirmatively to all three questions (Table 8). Additionally, one-fourth of respondents who perceived of trees as important in coping with climate change also had access to electricity, but did not have trees planted by household members.

Observed climate change and impacts

A significant positive relationship was found between perception of trees as important in coping with climate change, and observing an increase in temperature, and observing a decline in yield (both at 5 % level of significance). Studies have established that farmers' perceptions of climate change and the accompanying risks are influenced by the changes in climate that they observe and experience through the years (Maddison 2007; Bryan et al. 2013; Gbetibouo 2009; Frank et al. 2011). Research has shown that it is when farmers are able to directly relate their personal observations and experiences of climate-related phenomena with the attainment of their basic needs and goals that these observations and experiences begin to influence the way that farmers allocate their resources and adopt adaptation measures (Weber 2006; Lyle 2015; Maddison 2007). Further still, others have found that even when the reasons behind climate change are not fully understood, farmers remain perceptive of the impacts and adjust their production practices as needed (Cerdán et al. 2012).

Sources of climate information

Recognizing the value of trees in enhancing coping mechanisms to climate change was more likely among respondents who derived their climate information from government agencies (at 1 % level of significance). Interestingly, descriptive statistics show that government agencies were only the second most popular source of information, with mass media (i.e., television, radio) as the first. This suggests that government-led extension is an important factor toward transmuting perceived importance of tree roles into potential adoption of tree-based climate change adaptation measures. Meanwhile, it appears that climate change-related information and education campaigns of non-governmental organizations

Table 8 Farmers' household survey responses regarding the importance of trees in enhancing coping mechanisms to climate change, by access to electricity and trees planted by household member, Bohol, Philippines (n = 576)

(a) With access to electricity?	(b) Trees planted by household member?	(c) Do trees on-farm play important roles in enhancing your coping mechanisms to the impacts of climate change?				
		No	%	Yes	%	Total
No	No	61	11	29	5	90
	Yes	8	1	37	6	45
Yes	No	74	13	140	24	214
	Yes	28	5	199	35	227
Total		171	30	405	70	576

(NGOs) and cooperatives/local organizations have limited reach in the study area, as both were cited the least by respondents as sources of climate information. However, Grothmann and Patt (2005) caution that sometimes, even when farmers have reliable climate information (i.e., forecasts) and the means to adapt, the lack of intent to adapt still hinders them from taking positive action. This lack of adaptation intention was associated with (1) misaligned perceived versus actual/objective future climate risks, and (2) perceived lack of adaptive capacity against climate risks (Grothmann and Patt 2005). They suggest that instead of focusing purely on climate risks, providing climate risk information together with appropriate adaptation options can help address the gaps between information, perception, adaptation intention and action.

Conclusion

This study sought to understand the perceptions of Filipino smallholder farmers regarding climate change and their perceptions regarding the roles of trees in coping with such changes. Results showed that at the community level, farmers and community members were able to recall key climate events when compared to historical records of the relevant government agencies (i.e., PAGASA). Household surveys provided added insight by identifying specific attributes that had significant relationships to respondents' perceptions of climate change. Farmers and community members also recognized the ESs provided by trees, with FGD participants able to enumerate and rank important tree functions in reference to their experiences of climate-related change. In the context of Bohol, perceiving the importance of tree roles in building resilience to climate risks was less likely among respondents with higher levels of education and who derived income from tree products. Conversely, recognizing the value of trees in climate risk adaptation was positively associated with access to electricity and number of off/non-farm sources of income, having trees on their farm/s that were planted by household members, observed increase in temperature and decline in yield, and government as the source of climate information.

Jerneck and Olsson (2013) asserted that "poverty is a dis-incentive and a deeply rooted obstacle for agroforestry adoption" (p. 123). Indeed, our study found that where the necessary inputs are accessible (indicated by access to electricity and number of off/non-farm sources of income), there was also higher likelihood that farmers perceived trees as important components of their coping mechanisms to climate change. In essence, uptake of trees and agroforestry as an adaptation strategy to climate risks will depend on the capability of farmers to access necessary resources, although in some cases, lack of adaptation intention could still offset action (Grothmann and Patt 2005). The positive association of having trees planted by a household member with the likelihood of farmers' perception of tree roles as important in coping with climate change implies that personal identification with the proponents of an idea or technology may yield positive perception toward it. In light of this, the merits of farmer-to-farmer extension may also warrant consideration in future interventions promoting tree-based production systems for climate risk adaptation. Meanwhile, farmers' personal observations of climate change were also positive predictors of perception of tree roles as important, especially when examined in reference to their influence on the attainment of the household's basic needs and goals. Years of behavioral decision research has found that eliciting climate change adaptation and mitigation among individuals and groups requires information campaigns that command attention and appeal to emotion (Weber 2006). Congruently, the results of our research imply that perceiving trees as important in coping with climate change arose partly from having experienced negative impacts of those changes, and that information and education interventions could focus on drawing proactive responses from these experiences using participatory approaches.

Prior research has established that local government units are key to the success of mainstreaming climate change adaptation at the grassroots level (Lasco et al. 2008) and that one of the most effective means to this end is by making information more accessible (Roco et al. 2014). In promoting the potentials of tree-based agricultural systems for buffering against the impacts of climate change, our findings suggest that channeling climate and adaptation information through government agencies may be more effective than through other media. Bryan et al. (2013) found that agroforestry is usually best implemented through community-based groups, some of which are supported by NGOs that facilitate the formation of the groups, and provide technical expertise for their activities. In order to encourage sustainable agricultural production through agroforestry, assessment of locally-viable crop–tree–livestock combinations and analysis of market/value chains are in order, which would also benefit from provision of local government-led extension, backed by technical support from non-government partners.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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