Hungry Birds and Angry Farmers:

Using Choice Experiments to Assess "Eco-compensation" for Coastal Wetlands Protection in China.

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Summary. – The JYNNR – a Ramsar Site and Biosphere Reserve – is an important wintering ground for 15-18% of the world's population of Red Crowned Cranes, and faces significant pressures from current farming practices. This paper uses a choice experiment to assess farmers' preferences for an "eco-compensation" program targeting pesticide use by rural communities in and near the Jiangsu-Yancheng Coastal Wetlands Rare Birds National Nature Reserve (JYNNR). "Eco-compensation" is a term specific to China encompassing a growing range of incentive-based approaches to environmental management. To identify entry points for a co-management regime to reconcile rural welfare improvement with conservation, choice experiment data was collected by surveying in person 311 rural households in and near the JYNNR. We assess perceptions of the nature reserve, wetland birds, use and impact of pesticides, and preferences for contracts to mitigate pesticide impacts. Survey results suggest that the potential for conflict with the nature reserve is growing, and that pesticide management could be an effective entry-point for engagement. Data analysis points to several options for cost-effective contracts: granting rights to leave the program without penalty; increasing the share of household land enrolled significantly reduces the willingness-to-accept-payment (WTA). Longer contracts and larger reductions in pesticide use increase estimates of WTA, which interact meaningfully with observable farmers' characteristics.

Key words – China, choice experiments, payments for ecosystem services, coastal wetlands, pesticide use, co-management

Highlights

- We use choice experiments surveys to assess farmers' preferences for contracts to reduce pesticide use in and near a coastal wetlands reserve in China.

- We find growing conflicts between farmers and wetland birds, and that pesticide use can be effective entry-point for engagement.

- Choice experiments are found as a valuable community engagement tool to develop co-management pathways for land-uses around an important nature reserve.

- Several low-cost contract options are identified, including granting farmers autonomy in program participation choice.

1. INTRODUCTION

Though critical for addressing climate change and nourishing the world's fisheries, effective protection of coastal wetlands remains challenging in face of economic growth pressures, which fall disproportionately on coastal regions. More than one-third of the world's population lives along coasts and small islands – only 4% of the Earth's total land area – with population densities almost triple those of inland regions and fast-paced population growth set to continue (UNEP, 2006; MEA, 2005). The associated land-use and development pressures have led to significant wetlands losses.[1] Human activity directly related to agriculture has been a major contributor to global wetlands loss. The ongoing intensification of agricultural production to feed a growing world population will continue to escalate pressure on coastal ecosystems via nutrient enrichment and other human pressures (Elofsson *et al*., 2003; Forsberg, 1994; Turner *et al.*, 1999). At the same time, wetlands are important sources of rural livelihoods in the developing world.[2] Developing approaches that jointly target coastal wetlands conservation, rural livelihood improvement and regional agricultural and economic development is thus necessary for effective conservation (Tilman *et al*., 2002; MEA, 2005; Brandon *et al*., 2005).

We explore these issues in the context of the Jiangsu-Yancheng Coastal Wetlands Rare Birds National Nature Reserve in China, a Ramsar site and UNESCO Biosphere Reserve (Ma *et al.*, 2009). The wetlands complex – located in Yancheng municipality of Jiangsu Province on China's east coast – is an important wintering grounds for numerous migratory waterfowl along the East Asian-Australasian Flyway. Of particular note are one of the two wintering grounds in China for around 15%-18% of the world population

[1] An estimated 62-63% of natural coastal wetlands have been lost since the beginning of the 20th century – with Asia having the highest estimated rate of coastal wetlands loss globally – while the rate of loss for coastal wetlands has surpassed that for inland wetlands since 1990 onwards (Davidson, 2014). Some 35% of mangroves are estimated to have been lost (with some countries experiencing losses greater than 80%), while remaining coastal wetlands area suffers from substantial degradation, alteration or loss of estuaries, intertidal habitats and deltas, seagrass beds and saltmarshes globally (UNEP, 2006).

[2] At least 90% of Ramsar sites (i.e. wetlands designated as being of international importance under the Ramsar Convention) in Africa and Asia directly support human welfare (McCartney et al., 2010).

of the Red-crowned Crane (*Grus japonensis*) (Su & Wang, 2010; Lee & Yoo, 2010; Wang, 2008b).[3] This is an iconic, flagship species for China that is rated as endangered in the IUCN's Red List of Threatened Species (BirdLife International, 2013). Ongoing regional development, rural land-use transformation and climate change are placing significant and growing pressure on this wetlands habitat, and are creating conflict between the nature reserve and nearby rural communities (Ma *et al*., 2009). Local officials have reported increasing complaints from farmers denouncing encroachment and damage to crops by feeding wetlands bird populations, which are being displaced by development elsewhere along the coast.[4]

To address this, conservation local authorities have been keen to explore subsidy-based policy mechanisms. The goal is to engender a more proactive and collaborative relationship between farmers and the nature reserve by jointly addressing community livelihood issues and land-use impacts.[5] To implement such a policy farmers preferences need to be explored. This paper thus presents the results of a choice experiment administered to rural land users in and around the reserve to explore options for mitigating the impacts of nearby agriculture on the wetlands ecosystem and bird populations.[6] Households were asked to assess various contracts for a potential agri-environmental scheme targeting household pesticide use in agriculture.

Choice experiments have grown in popularity as an effective tool to elicit farmer preferences for agri-environmental payment schemes in both developed-world and, increasingly, developing-world contexts. Earlier applications in the context of rural development include studies aimed at livestock evaluation by pastoralists and subsistence farmers (Scarpa et al. 2003; Ruto et al. 2008; Roessler et al. 2008). Recent

[3] The wintering population in China totals around 400-500 birds (Su and Wang 2010). There are another 1,000-1,050 birds at four locations in North and South Korea, while there is a non-migratory resident population in Japan of around 1,200 birds (Su and Wang, 2010; Lee and Yoo, 2010; Wang, 2008b).
[4] This is from several discussions with local officials during survey fieldwork.
[5] In several discussions during exploratory fieldwork local officials expressed serious reservations about directly raising the topic of bird-related crop damage with rural households in the survey, suggesting that this would only serve to reinforce a victim-offender dynamic between these communities and the reserve.
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applications include assessment of different contract configurations under the EU's Common Agricultural Policy (Ruto & Garrod, 2009; Espinosa-Godad *et al.*, 2010; Christensen *et al.*, 2011; Broch *et al.*, 2013; Schulz *et al.* 2014; Lienhoop & Brouwer, 2015; Santos *et al.*, 2015; Beharry-Borg *et al.*, 2013; Greiner *et al.*, 2014), and elicitation of rural land-user and agricultural producer preferences for a schemes targeting a range of different environmental impacts in developing world contexts (see, for example, Pienaar *et al.*, 2014; Selassie & Kountouris, 2010; Barton & Bergland, 2010; Cranford & Mourato, 2014; Blazy *et al.*, 2011; Kaczan *et al.*, 2013).[7]

Our choice experiment application is novel for several reasons. First, the results are directly used for policy simulations, which are used both to inform the design of a potential subsidy scheme and to educate local conservation officials on the value of community consultation by, for example, revealing the significant savings in subsidy rates achievable if the scheme is made voluntary. Secondly, while the choice experiments are fundamentally to assess farmer willingness-to-accept payment (WAP) for targeted land-use change, they were also used as a formalized initial engagement and consultation with these communities, envisioned as a first-step towards engendering an adaptive co-management framework for wetlands conservation and the mitigation of agricultural impacts. As such, this is one of the few works to highlight the value of choice experiments as a community engagement tool.

Finally, this research also feeds into China's ongoing experimentation with incentive-based approaches to conservation, under the broad heading of "ecological compensation" ("eco-compensation" for short), since the choice experiments were conducted to inform the design of an eco-compensation pilot for wetlands conservation, and were presented to households as such. "Eco-compensation" is a term specific

[7] This includes conservation-contingent rural development programs in Botswana (Pienaar et al., 2014), fishing permits for wetlands conservation in Ethiopia (Selassie & Kountouris, 2010), irrigation water in India (Barton & Bergland, 2010), credit-based agroforestry Payment for Ecosystem Services in Ecuador (Cranford & Mourato, 2014), agri-environmental innovations in banana production in the Caribbean (Blazy et al., 2011), and Payments for Ecosystem Services to reduce deforestation in Tanzania (Kaczan et al., 2013). Table 1 of Lizin *et al*. (2015) provides an excellent summary of the literature on discrete choice experiments for valuing land use restrictions.

to China that is becoming an important policy component of its evolving environmental management regime (Zhang & Crooks, 2012; Zhang & Bennett, 2011). It encompasses a growing range of incentive-based approaches at various levels, including interregional fiscal transfer mechanisms targeting specific environmental outcomes, such as improved management of shared watersheds, and Payments for Ecosystem Services (PES) approaches that directly engage with rural land users to incentivize environmentally-friendly land uses and land-use change (Bennett, 2009; Zhang *et al.*, 2010a).[8] Our research concerns two priority areas for the development of eco-compensation pilots as per the China's Ministry of Environmental Protection – nature reserves and key ecological function zones (MEP, 2007b).[9] It thus hopes to provide seminal insights for China's evolving eco-compensation policy developments.

Section 2 below describes in more detail the context and conservation challenges of Jiangsu's coastal wetlands and of coastal wetlands in China overall, illustrate details of the survey, and presents survey results concerning the potential for conflict with the nature reserve and household perceptions regarding pesticide use and impacts. The choice experiment design and modeling approach are presented in section 3, followed by the estimation results and policy simulations in sections 4 and 5. Section 6 concludes with a broader look at the value of greater utilization of community engagement and co-management approaches for China's rural environmental management challenges.

[8] Over the past decade China has been witness to a growing diversity of national and provincial-level experiments in environmental policy under this broad heading (Bennett, 2008; Zhang et al., 2010b). This has led to national uptake in the goal of creating an effective regulatory framework governing eco-compensation, and encouragement of provincial pilots to inform how to operationalize the concept (Zhang and Crooks, 2012). Both the current and previous national 5-year plans of China have placed strong emphasis on the promotion of eco-compensation programs and policies, and the National Development and Reform Commission has been tasked with the development of a national eco-compensation ordinance (Zhang et al, 2010a; Zhang and Bennett, 2012).

[9] These priority areas are: watersheds, mineral development areas, key ecological function zones and nature reserves (MEP, 2007b).

2. THE JIANSU-YANCHENG COASTAL WETLANDS

The study area in Jiangsu Province is representative of the challenges China faces in conserving its remaining coastal wetland in general. China's coastal wetlands cover 5.798 million ha (10.85% of the country's total wetland area) and face severe and growing pressure from decades of fast-paced economic growth. These are exacerbated by the associated trends of rural migration to urban centres and generally from the interior to coastal regions, with a concurrent intensification of agriculture in response to changing food demand (Lu & Jiang, 2004; Zhao & Song, 2005; Jiang *et al.*, 2015; Wang, 2015).[10] Around 57% of China's natural coastal wetland area and 37% of habitat in intertidal areas along the Yellow Sea coast are estimated to have been lost since 1950, compared to a 33% loss of wetlands overall in China during 1978-2008 (An *et al*., 2007; Niu *et al*., 2012; UNDP, 2006).[11]

Jiangsu Province contains 650,000 ha of coastal wetlands: a quarter of coastal mudflat wetlands in China (Zhao & Song, 2005). These consist primarily of extensive intertidal mudflats, tidal creeks and river channels, salt marshes, reed beds, and marshy grasslands all of which support numerous plant and animal species. The Jiangsu-Yancheng Wetlands Rare Birds National Nature Reserve (hereafter JYNNR) was established in Yancheng Municipality in 1992 to protect these important wetlands, and has a total area of 247,260 ha. These consist of a core zone of 22,596 ha that contains primarily natural habitat, a buffer zone of 56,742 ha that supports both natural ecosystems and agricultural land uses (cropping and aquaculture),

[10] China's coastal provinces contain 43% of its population, with population densities almost five times those of the interior. These coastal regions contribute 63% of its GDP, with average annual GDP growth rates for 1996-2014 around 11.5% compared with 8.9% for inland provinces (China Statistical Yearbook, Various Years).

[11] Using official statistics and other academic sources, An et al (2007) estimate that during 1950-2000, China lost 21.6% of natural wetland area overall (an estimated loss of loss of 9.9 million ha), 51.6% of coastal wetlands, 23% of freshwater swamps, 16.1% of lake wetlands and 15.3% of rivers wetlands. Based on Landsat and CBERS-02B remote sensing data, Niu et al (2012) estimate that natural wetland area in China declined by 33% during 1978-2008, from 309,296 km^2 to 207,897 km^2.

and an experimental zone of 167,922 ha that has a mixture of land-use types in addition to scattered natural ecosystems (MEP, 2013; Zhao & Song, 2005).[12]

(a) Conflicts between Development and Conservation

Increasing regional development pressures have adversely affected migratory bird populations along these routes. While elsewhere the populations of Red Crowned Crane remain stable or have increased, that which migrates along eastern China has steadily declined in recent years. Wintering populations in and around Yancheng are estimated to have collapsed from 1,128 cranes during 1999-2000 to around 400 cranes during the winter of 2008-2009, with a more recent rate of decline of 50-150 birds per winter (Wang, 1997; Wang & Yang, 2005; Su, 2008; Wang, 2008, 2010; Su & Zou, 2012). Human encroachment on wetlands habitat has meant that farmland bordering the reserves and in the buffer and experimental zones has become a precious habitat and important source of food and foraging for wetland cranes and other waterfowl in recent years.[13] Bird population surveys in 1999, 2000 and 2001 indicated that 37%, 38%, and 29% of cranes, respectively, foraged for food and especially grain in deserted paddies, while less than 30% of the cranes are now recorded in natural habitats (Ma et al, 2009).[14] More recent work has found that around one fourth of feeding time was spent in farmlands in comparison to reed beds and grasslands habitats (Li *et al*., 2013). This has resulted in increasing conflicts between nearby farming communities and the nature reserve, a common challenge facing protected areas globally (Sessin-Dilascio

[12] The JYNRR administration has ownership of the entire core zone and 900 ha of the experimental zone (where the administrative infrastructure is situated). The lands in the buffer zone and experimental zone are owned by multiple different stakeholders, ranging from the national government (via state-owned salt works and forest farms), the Yancheng Municipal Government, and local collectives and villages (ADB, 2011).

[13] It is estimated that around 53-67% of Yancheng's wetlands were lost during 1987-2007 due to dike construction, port development, and conversion of land to farming and aquaculture (Sun & Liu, 2010; Ke *et al*., 2011).

[14] The distribution range and pattern of this wintering population has been shrinking since the late 1980s – from a previously wide and continuous distribution to an increasing share of the total wintering population (60-70%) concentrated in and near the core zone of the JYNNR (Ding & Zhou, 1982; Lü & Zhou, 1990; Wang *et al*., 2005; Su *et al.*, 2008; Ma *et al.*, 2009; Su & Zou, 2012).

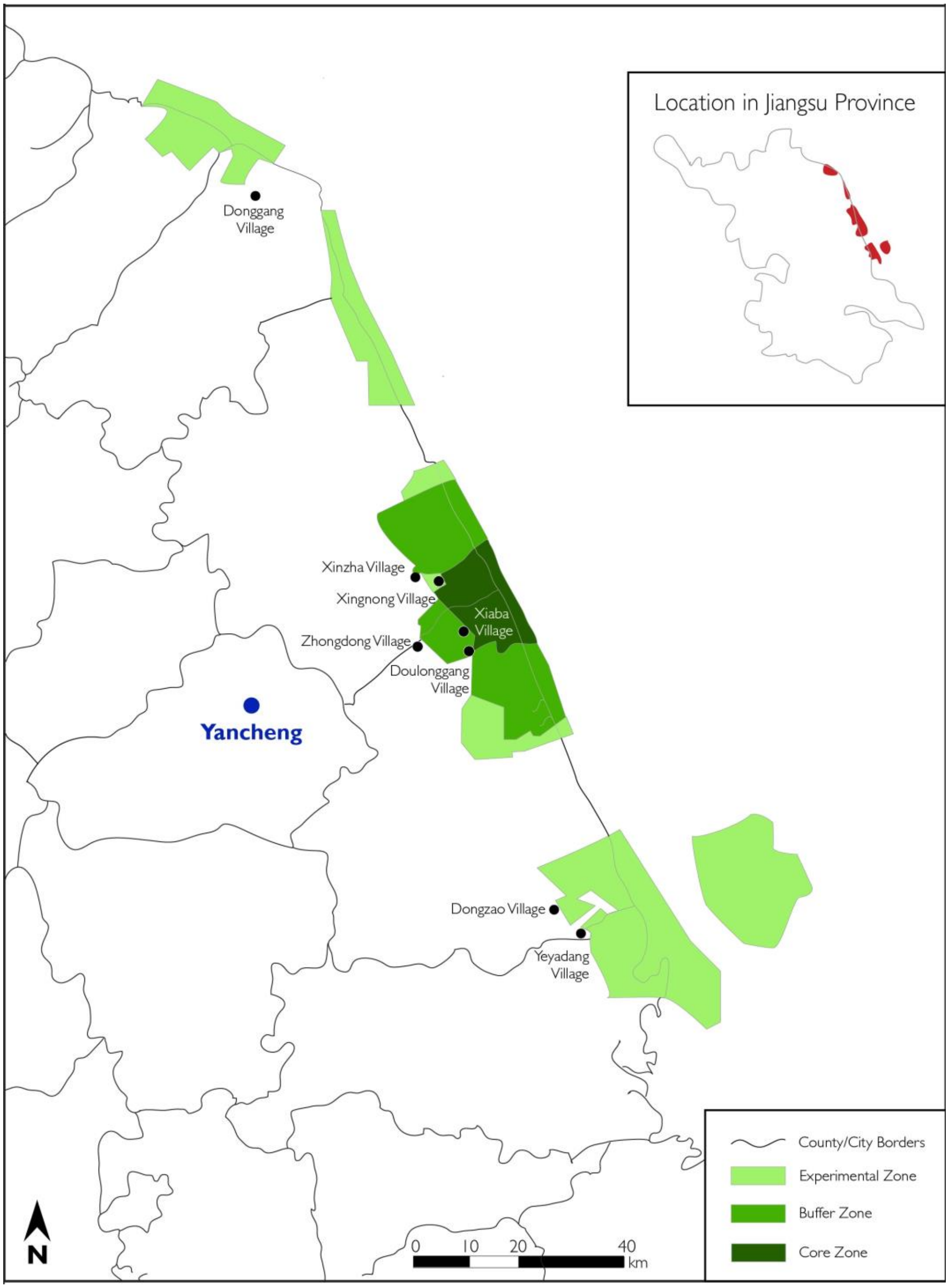
et al., 2015; Brandon *et al*, 2005; Brandon & Wells, 1992). It has also increased the potential for agrochemicals to have greater impacts on wetlands bird populations.[15] Su & Zou (2012) document numerous instances of Red Crowned Cranes in or near the JYNNR being poisoned due to agrochemicals, with available evidence suggesting a minimum of two cranes per year during 1990-2012, with this likely a lower bound on the true rate.

To examine these issues in more depth, a random sample of rural households was surveyed in 2012 from villages in and near the Jiangsu-Yancheng Wetlands Rare Birds National Nature Reserve (hereafter JYNNR). Eight villages were chosen to capture a range of contexts in the region: three villages are inside the nature reserve – Doulonggang and Xiaba villages are in the southern buffer zone, and Xingnong village is in the western experimental zone; two villages are near the core zone but outside the reserve – Xinzha and Zhongdong villages; and three villages are outside the reserve and far from the core zone – Donggang village borders the northern experimental zone, and Dongzao and Yeyadang villages border the southern experimental zone. Two village small groups were sampled from each village, with 19-22 per households randomly selected in each small group, for a total of 311 households surveyed.[16]

[15] Agrochemicals can have significant adverse effects on wetland birds and ecosystem viability via reductions in biodiversity (Mineau & Whiteside, 2006; Guerrero *et al*., 2012; Sánchez-Bayo, 2011; Szabo *et al*., 2009). Pesticides in particular can have a range of important adverse health impacts on bird populations that frequent agricultural fields, including reduced reproductive activity, eggshell thinning or acute mortality, and neurological and muscular impacts, with outcomes ranging from reduced foraging activity, loss of ability to fly, to death as the result of paralysis of the respiratory muscles (UNEP/CMS, 2014). High pesticide use has been identified as a potentially significant long-term threat to the ecological character of the Jiangsu-Yancheng wetlands, with the increasing use of pesticide-and-hormone-coated wheat seeds found to often coincide with the arrival of the wintering red-crowned cranes in late October and early November, leading to the poisoning death of 3-5 cranes each sowing season (ADB, 2011).

[16] "Village small group" is a formal term in China indicating a specific sub-village neighborhood cluster. Survey sample descriptive statistics are presented in APPENDIX II.

Figure 1. *Survey Village Locations, Jiangsu Yancheng Wetlands Rare Bird National Nature*



Adapted from MEP (2007). Graphics courtesy of Diana Schoenbrun.

Household survey responses confirmed the potential for conflict between nearby communities and the nature reserve; based on retrospective recollection, households generally reported increasing numbers of birds in their fields since 2001 and 2008, as well as crop damage due to bird visitations.[17] Those in villages inside the JYNNR or near the core zone were more likely to feel that bird populations visiting their fields had “increased somewhat” or “increased a lot” in comparison to the base years, while those who said there was no change in numbers often still indicated that large numbers of birds visited their fields.[18] Crop damage from birds was also reported in the survey, with 87-91% of these occurring in Xiaba and Xingnong villages in the JYNNR.[19] Nature reserve officials also expressed concern that the number and frequency of complaints about bird damages in nearby villages had been increasing in recent years.[20]

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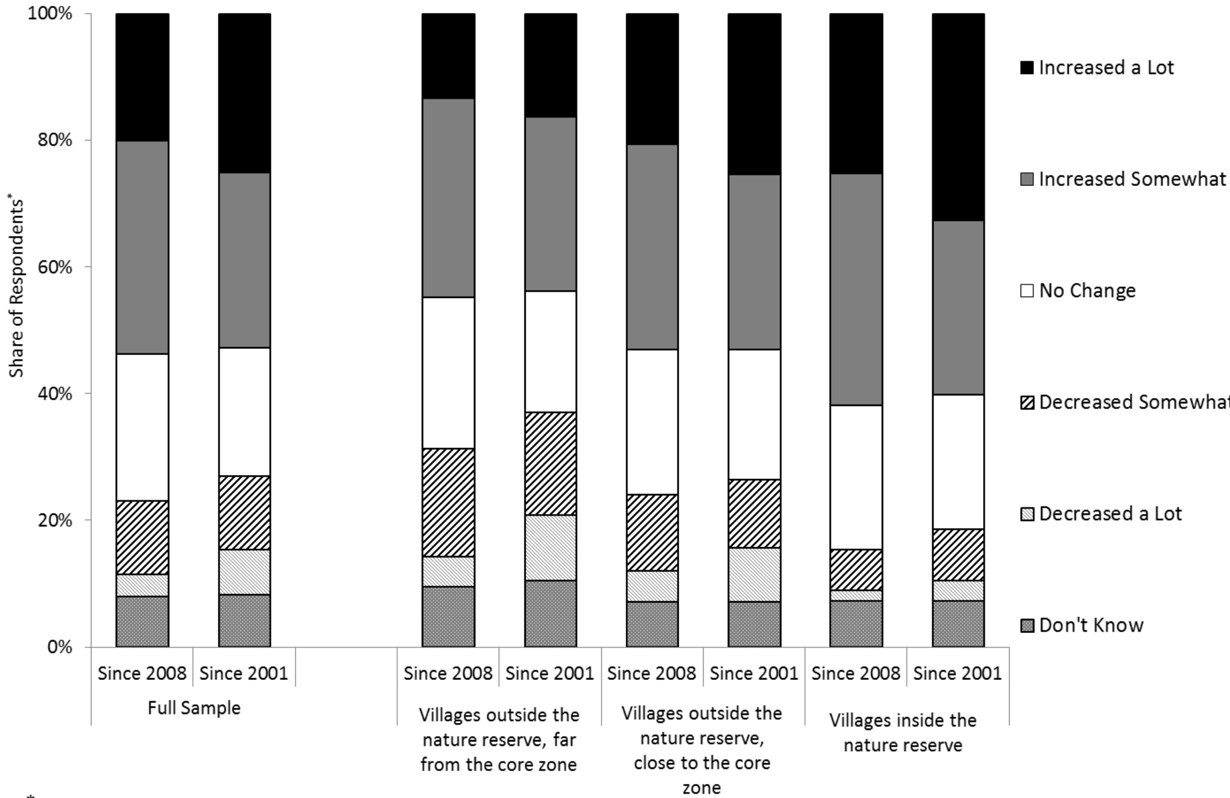
[17] To facilitate recall, mention of the Beijing Olympics was used as an anchor point for 2008.

[18] Comparison of means tests found statistically significant differences between (1) Households in villages in the JYNNR compared to the rest, and (2) Households in villages in the JYNNR or near the core zone compared to households in villages far from the core zone. T-tests were conducted assuming unequal variances between groups, with the two-tailed test significant at 5% or less.

[19] According to the household survey data, birds damaged around 2-3% of plantings each year, with average damage of around CNY 3,000- 4,000 per hectare. This compares with average damages from drought of around CNY 5,400 – 6,100/ha, and from flooding/waterlogging of CNY 6,600-8,500/ha. These latter two affected around 3.8-6.5% and 2.8-9.8% of plantings, respectively.

[20] This information obtained from direct discussions with nature reserve officials during the survey work.

Figure 2. *Survey Household Perceptions of Changes in Number of Birds Visiting Agricultural Fields*



* Household responses are averages of responsese for each bird species seen.

(b) Targeting Pesticide Use in Nearby Agriculture

Nutrient overloading is an important stressor of China's remaining wetlands, as is globally, with severe and rapidly growing adverse impacts (Jiang *et al.*, 2015; An *et al.*, 2007; Gabric & Bell, 1993; Turner *et al.*, 1999; MEA, 2005).[21] An *et al*. (2007) documents that both point and non-point source water pollution has become a serious problem for China's wetlands, and that during 1950-2000 annual consumption of fertilizers in China increased 530 times, with 50-70% of fertilizers ending up in natural wetlands either via direct discharge or accumulated runoff. China has also become the world's largest producer and consumer

[21] Around 20% of N fertilizer applied to agricultural systems moves into aquatic ecosystems, with impacts of nutrient loss from agroecosystems including groundwater pollution and increased nitrate levels in drinking water, eutrophication, increased frequency and severity of algal blooms, hypoxia and fish kills, and 'dead zones' in coastal marine ecosystems (Galloway et al. 2004; Bouwman et al. 2009).

of pesticides – with average application rates of 14 kg/ha and higher rates in wealthier and warmer regions such as Jiangsu Province (Wilkes & Zhang, 2016; Zhang *et al.*, 2016). This has resulted in significant soil and water pollution, adverse health impacts to farmers and food safety issues (Wilkes & Zhang, 2016; Zhang *et al.*, 2012; Zhao *et al*., 2014; Qiao *et al.*, 2012; Sun *et al.*, 2012; Chen *et al*., 2011). An important dimension of these challenges is that agriculture is still dominated by small-scale household farming – the majority of crop production is provided by around 200 million households with average farm size of around 0.6 ha (Huang *et al.*, 2012). This argues for adoption of approaches that can directly engage these rural communities.

Contracts regulating pesticide use were selected as context for the choice experiment scenarios since households would ostensibly have a vested interest in adopting better practices, and targeting sustainable agriculture (rather than bird impacts) would avoid engendering perceptions of the nature reserves as a burden – wherein "victim" communities would increasingly feel they are owed compensation by the nature reserve – by framing the relationship more positively and collaboratively. Other work on Payments for Ecosystem Services (PES) has also highlighted the pitfalls of creating direct incentives for ecosystem services provision via crowding out of intrinsic motivations (Farley & Costanza, 2010; Muradian *et al.*, 2010; Sommerville *et al.*, 2009; Vatn, 2010).

Survey responses indeed suggest over-use of pesticides, and that cost-effective options—such as providing training and technical support—could be explored for targeting and mitigating impacts. Most households, for example, indicated that their frequency of pesticide application had increased "somewhat" to "a lot" since 2008, with the main reasons for this stated as being an increase in pest populations and pesticide-resistant pests. Similarly, most respondents also observed that pest populations had increased "somewhat" to "a lot" since 2008. Only 17% of surveyed households reported that they had been trained in how to properly use pesticides, while fully 71% of household indicated that an important factor in determining the timing of pesticide applications was seeing pests in their fields. This suggests that a need exists to provide training and extension to households regarding pesticide use, which could help to not only reduce impacts but could increase efficiency in use of agricultural inputs. In general, an effective pesticide application regime is based on a range of considerations (e.g. season, temperature, climate and crop choice) other than simply “I spray when I see bugs”. Further compounding this, households generally did not view pesticides as having significant impacts on water resources, and much less on wetlands birds. Other findings in the literature also point to lack of awareness of farmers in China regarding the negative impacts of chemical inputs, and their appropriate use (Sun *et al.*, 2012).

Figure 3. *Household Pesticide Application Frequency, Application Reasons, and Pest Population Changes*

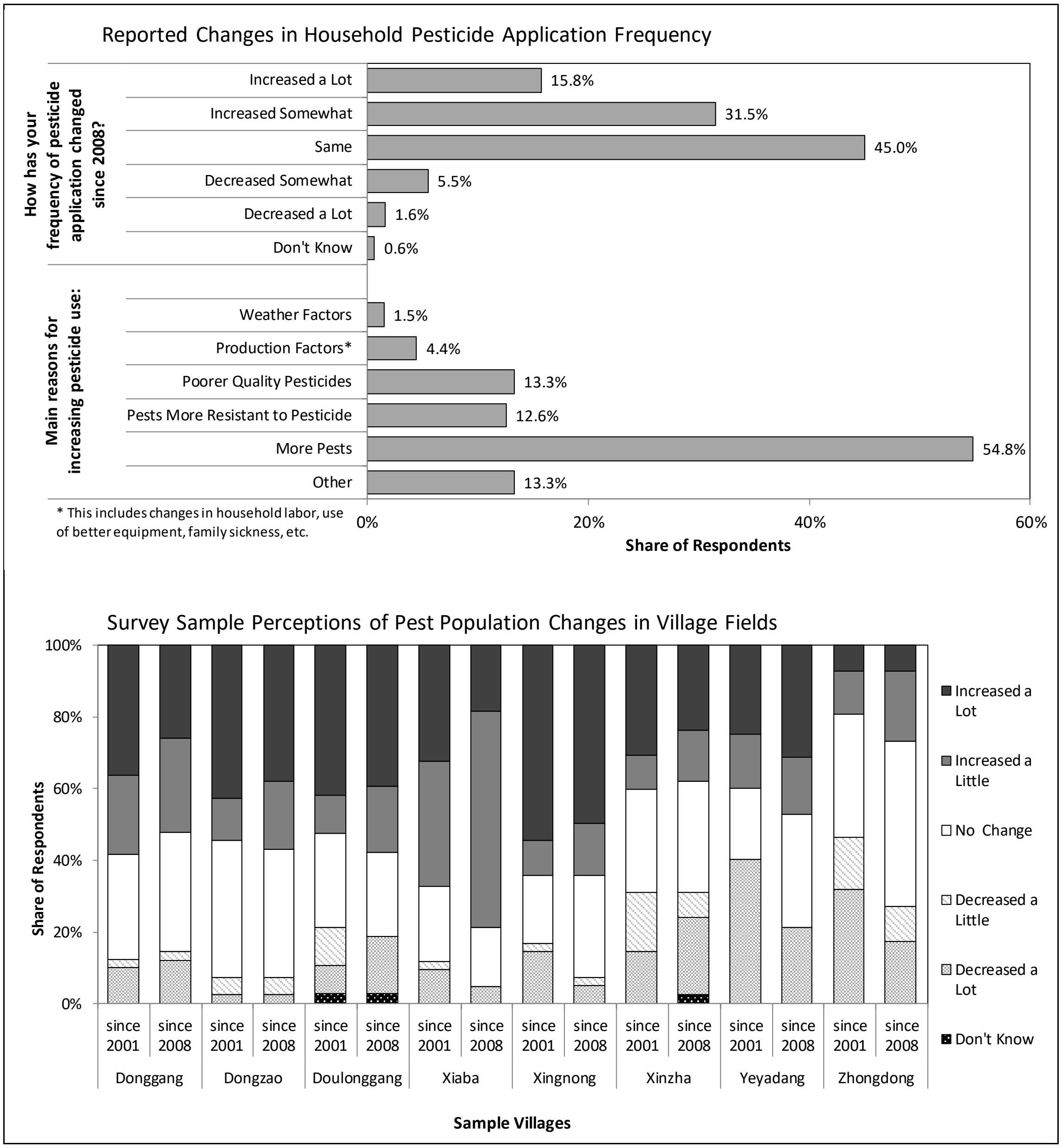
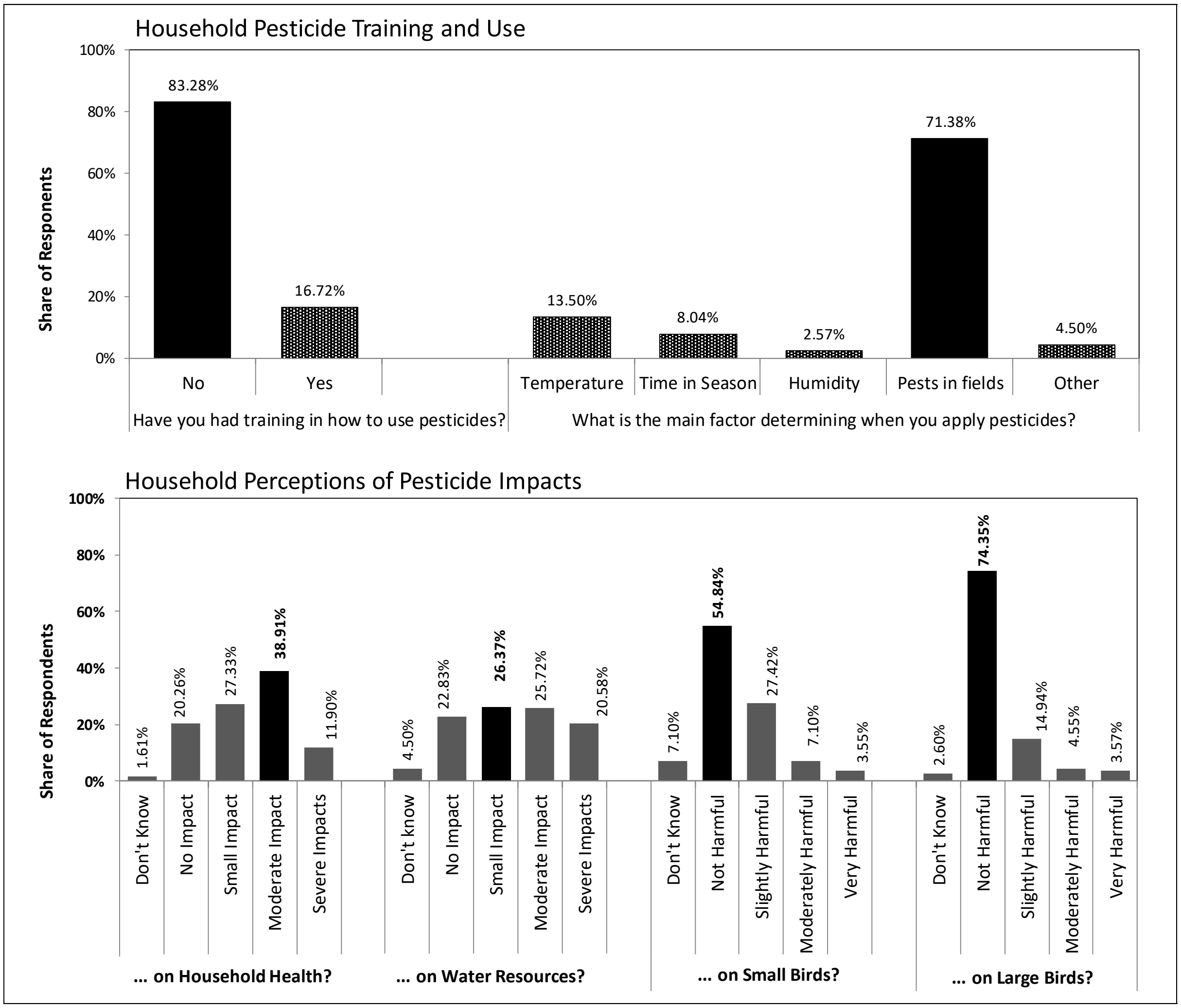


Figure 4. *Household Pesticide Training, Use and Perceptions*



Pesticide use was also targeted as a first step to inform the development of a regional eco-labelling scheme for organic agriculture, which was also being explored as an approach for ameliorating conflicts between conservation and regional rural development. Payment for ecosystem services (PES) is an increasingly common approach used internationally to complement or catalyze an enabling policy environment for sustainable agricultural development (Lipper & Neves, 2011). Hope *et al*. (2008) find that transitional payments are often necessary to overcome farmer constraints to adopt organic farming. Agriculture remains an important sector for Yancheng. The municipality is the largest producer of agricultural products and by-products (e.g. grains, cotton, oil, fruits, vegetables, fowl, eggs and fish) in

Jiangsu province, with eight counties producing nationally recognized commercial grains, one county producing high-quality oil plants and six counties producing high-quality cotton. It is also an important producer of aquatic goods, animal and plant products (ADB, 2007; ADB, 2011). Agriculture contributed 17% of 2011 GDP for Yancheng, and made up a mean and median of 42% and 32% of 2011 income for the survey households, respectively (YSB, 2012; authors' survey data).

3. HOUSEHOLD PREFERENCES FOR CONTRACT DESIGN

In the survey farmers were presented with the choice experiment scenario explaining that the government was planning to launch a 10-year program in the region to reduce pesticide use, which would include provision of technical support and guidance, improving availability of low-toxicity pesticides, and an annual cash subsidy. To minimize hypothetical bias, the survey was consequential. Specifically, the scenario was presented to respondents in a way to indicate that the government was planning to launch such a program, and that the survey was for the purpose of informing its design.[22] The attributes and levels of the choice experiment, which were finalized after extensively pretesting the choice experiment in the first village in the sample, are presented in Table 1 below.[23]

[22] The full script of the choice experiment scenario is presented in Appendix I.

[23] The final levels of the attributes were selected based in part on how other government policies targeting rural land use in China are generally configured – and thus what would be realistic for the local government partner to implement – and in part to facilitate communication of the scenario to the respondents. Focus groups and pretesting in the first village found these levels to be easily understandable and generally considered to be realistic. Findings in the literature also argue for the use of standard increments in levels to facilitate communication. See, for example, Manski and Molinari (2010).

Table 1. *Choice Experiment Attributes and Levels*

Attribute	Level
Contract Length	1 Year
	5 Years
	10 Years
Release Option	Cannot Leave the Program
	Can Leave the Program Without a Penalty
Land Area	20% of Household Land Area Enrolled in the Program
	50% of Household Land Area Enrolled in the Program
	100% of Household Land Area Enrolled in the Program
Pesticide Use	During the contract period participants will, "with guidance", reduce annual pesticide use by…
	...5% in comparison to 2011.
	…10% in comparison to 2011.
	…20% in comparison to 2011.
	…30% in comparison to 2011.
Annual Cash Subsidy	CNY 10/mu*
	CNY 50/mu
	CNY 80/mu
	CNY 120/mu

* 1 mu ≈ 1/15 hectares

The experimental design for the allocation of attribute levels to alternatives in the various choice tasks was obtained by extracting from the full factorial a subset with the property of having orthogonal differences between attribute levels (Scarpa & Rose, 2008). A total of 72 choice tasks were created in this fashion, blocked into nine choice tasks sequences with each including eight choice tasks. A complete design was thus obtained for every nine respondents. We note in passing that this approach to the selection of the full factorial allows identification of all the main effects of interest, but it may not be as efficient as other approaches requiring a-priori assumptions (such as D-error minimizing or other approaches). Although the design was pretested, in an efficiency measure (we used the Bayesian D-error median) comparison with a D-error minimizing design based on the pre-test priors did not suggest an efficiency increase strong enough to justify a change in design criterion. As a consequence, we opted to use for the entire field survey the fraction of the factorial based on the orthogonal in the difference approach. Its ex-post efficiency, using equations (25) and (26) in Scarpa and Rose (2008) resulted quite high, with values of 2 and 1.4 for the D-error from point estimates and the D-error Bayesian, respectively.

Box 1. *Excerpt from the Survey Choice Experiment Instrument*

<u>BLOCK 1</u>

Ok, not we will formally begin to ask you to compare and choose. You can choose one of the three program schemes. If you do not like any of the three schemes, you can also choose not to participate in the program.

* In the survey just completed, your household in total used _____ of pesticides (fill in the amount used) in 2011.

Choice Group 1

	Program Scheme 1	Program Scheme 2	Program Scheme 3	
Contract Length	1 year	5 years	10 years	Don't participate in the program
Release Option	You can leave the program without penalty.	You can leave the program without penalty.	You cannot leave the program.	
Land Area Enrolled	20% of your land will be enrolled in the program.	50% of your land will be enrolled in the program.	100% of your land will be enrolled in the program.	
Pesticide Use Reduction	During the contract period you will, with guidance, reduce annual pesticide use by 10% in comparison to 2011.	During the contract period you will, with guidance, reduce annual pesticide use by 30% in comparison to 2011.	During the contract period you will, with guidance, reduce annual pesticide use by 20% in comparison to 2011.	
Annual Cash Subsidy	CNY 80/mu*	CNY 50/mu	CNY 120/mu	

* 1 mu ≈ 1/15 hectares

We model farmers choice of contracts invoking the standard random utility framework. We use both a standard random utility specification with fixed coefficients (Multinomial Logit Model), as well as an error-component model to induce correlation among utilities of contract alternatives different from the status-quo or "opt-out" (no contract) option. Often when this options is included in the set of alternatives in choice scenarios can cause respondents to regard the status-quo alternative in a systematically different manner from the designed alternatives involving changes from the status-quo; status-quo is actually experienced, while the experimentally designed options are hypothetical (see Scarpa et al. 2005 for details). As a result, the utility from experimentally designed hypothetical alternatives are more correlated amongst themselves than with the utility associated with the status-quo, and typically display larger variance.

This may be captured by a specification with additional errors accounting for this difference in correlation across utilities. Correlation is a consequence of the fact that experimental alternatives share this extra error component, which instead is absent from the utility of the status-quo alternative. Previous studies have found theoretical reasons for status-quo bias (Samuelson & Zeckhauser, 1988; Haaijer, 1999; Haaijer, Kamakura & Wedel, 2001), and choice experiment applications in environmental economics (see, e.g., Lehtonen *et al.* 2003; Kontoleon & Yabe, 2003) found these effects to be significant. In a Monte Carlo study, Scarpa, Ferrini & Willis (2005) compare the performance of a number of standard random utility models addressing the status-quo effect. They find a flexible mixed logit error component model—which can induce a correlation structure across alternatives similar to that of a nested logit model—to be more robust to potential misspecification than the latter. We hence employ such a flexible error-component specification here. We assumed the following random utility function structure,

$$U(c_1) = V(c_1) + \varepsilon + u_1 = \beta x_1 + \varepsilon + u_1 \quad [1]$$

$$U(c_2) = V(c_2) + \varepsilon + u_2 = \beta x_2 + \varepsilon + u_2 \quad [2]$$

$$U(c_3) = V(c_3) + \varepsilon + u_3 = \beta x_3 + \varepsilon + u_3 \quad [3]$$

$$U(c_4) = V(c_4) + u_4 = \alpha + u_4, \quad [4]$$

where $V(c_i) = \beta x_i$ are the indirect utility functions, c_1-c_3 are the designed choices and c_4 the status quo alternative, β are taste coefficients for the attributes of the alternatives, α is a non-random status-quo specific constant, x_1-x_3 are the attributes of each alternative, ε is a zero-mean normal error component inducing correlation amongst designed alternatives, and u_i is the usual unobserved utility component distributed i.i.d. Gumbel.

Given this specification, the marginal probability of observing a sequence of choices t(n) from individual n is therefore,

$$P\big(t(n)\big) = \int \prod_{t=1}^{t=8} \frac{\exp(\beta' x_{tni} + 1(.)\varepsilon_{ni})}{\sum_j \exp(\beta' x_{tnj} + 1(.)\varepsilon_{nj})} \varphi(\varepsilon|\sigma^2) d\varepsilon \quad [5]$$

with ε_{tj}=0 when j=4. The standard random utility characterization is thus a special case of this whereby the ε_{tj} have a degenerate distribution with 0 mean, and $1(.)$ is an indicator function that takes the value of one for alternatives different from the status quo, zero otherwise. In estimation, unconditional choice probabilities are approximated by simulating the integral by the average computed at Halton draws (Train, 2003; Hess, Train & Polack, 2006).

Of relevance for this work is the compensating surplus (CS) welfare measure, which is calculated as

$$CS = \frac{\ln \sum_k \exp(V_0) - \ln \sum_k \exp(V_1)}{\beta_{inc}} \quad [6]$$

where V_0 and V_1 are the indirect utility functions for before and after the change under consideration, and β_{inc} is the marginal utility of income, which in this case is capture by the parameter on the subsidy level attribute. Following Hanemann (1994), the reduced form of equation [6] for a change in attribute k is as follows:

$$W_k = -1\left(\frac{\beta_k}{\beta_{Cash\ Subsidy}}\right) \quad [7]$$

This represents the marginal willingness to pay for a 1 unit increase in attribute *k*, or the marginal rate of substitution between attribute *k* and the unit of money.

Also of interest are policy simulations based on model estimates. In particular, predicted sample program enrollment probability for farm household n ϵ {1,2,….,N}, given pesticide use contract with configuration *k* with vector of attributes x_k, vector of household-specific indicator variables y_{kn}, and population preference parameter vector $[\beta_x | \beta_y]$, can be estimated with the binomial logit characterization

$$P(Enrollment(k) = yes)_n = \frac{\exp(\beta_x x_k + \beta_y y_{kn})}{(1+\exp(\beta x_k))}. \qquad [8]$$

Based on this characterization, minimum program payments C_{min} for a given configuration k are thus the level of cash subsidy at which the model predicts the targeted enrollment rate R,

$$\sum_{n=1}^{N} \frac{\varphi(P(Enrollment(k)=yes)_n | C_{min})}{N} = R, \qquad [9]$$

where

$$\varphi(.) = \begin{cases} 1 & if\ P(Enrollment(k) = yes) > 0.5 \\ 0 & otherwise. \end{cases} \qquad [10]$$

For the policy simulations conducted later in the paper, we estimate C_{min} for R = 1 (i.e. the minimum subsidy rate necessary to predict 100% enrollment of sample households).

4. RESULTS

Useable choice experiment data was collected from 288 households, for a total of 2,304 choices.[24] The choices made in this sample were found to be distributed quite evenly across the four possible alternatives, indicating that both the attributes and the levels were well-chosen in terms of eliciting a balanced variety of trade-offs across pesticide use contracts.[25] To explore the existence of systematic preference heterogeneity based on observable characteristics, five different [0/1] indicator variables were used as proxies for household type, to be interacted with choice attributes. These were:

(1) whether or not households reported they were trained in pesticide use,

(2) whether or not households felt that pesticide use had "moderate" to "significant" impacts on household health,

[24] The first day of survey work was utilized to test choice attribute levels and respondent receptivity to the choice scenario, while two households in the remaining sample refused to participate in the choice experiment portion of the survey.

[25] Of out 2304 choices, status quo was chosen in 681 (29.56%), alternative 1 was chosen in 543 (23.57%), alternative 2 was chosen in 489 (21.22%), and alternative 3 was chosen in 591 (25.65%).

(3) whether households “agreed” or “strongly” agreed that increased use of pesticides increases crop yields, and either

(4) whether or not a household was in the bottom 33% percent, or

(5) the top 33%, of the sample distribution of total household pesticide expenditures in 2011.[26]

Table 2. *Household Attitudinal Variables Interacted with Choice Attributes*

Variable Name	Variable Code	Share of Sample=1
Pesticide Training	1=Household received training before in the use of pesticides; 0=Otherwise.	18%
Pesticide Health Impacts	1=Household believes that pesticides have a "moderate" to "severe" impact on household health from use in household fields; 0=Otherwise.	51%
Pesticide Yield Boost	1=Household "agrees" or "strongly agrees" that applying more pesticides boosts crop yields; 0=Otherwise.	45%
High Pesticide Expenditures	1=Household is in the top 33% of the sample in terms of total pesticide expenditures in 2011; 0=Otherwise.	33%
Low Pesticide Expenditures	1=Household is in the bottom 33% of the sample in terms of total pesticide expenditures in 2011; 0=Otherwise.	33%

Model results for the MNL specification are presented in Table 3 below, and accord with expectations. Households generally prefer shorter contract lengths with the option of leaving the program without penalty, smaller levels of required pesticide use reductions, and higher subsidies. Households also prefer to have more of their land enrolled in the program, perhaps to offset the expected fixed costs of participation. Models with interaction terms found statistically significant parameter estimates for

[26] The sample average total pesticide expenditures for the bottom third of the sample was CNY 359/year, for the middle third it was CNY 976/year, and for the top third it was CNY 2949/year for 2011.

pesticide training interactions with contract length and pesticide use reduction, pesticide health impact interactions with contract length and pesticide use reduction, pesticide yield boost interactions with release option, land area and pesticide use reduction, and high pesticide expenditure interactions with release option and cash subsidy. The results of our estimates indicate that observable household characteristics are able to capture important dimensions of preference heterogeneity in the sample. This is important for the feasibility of program design, where preference heterogeneity can only be realistically accounted for by what is observable. The heterogeneity of preferences for pesticide use reduction appears to be particularly important and complex, with changes in sign depending on whether households are cognizant of health impacts, are trained in pesticide application, and feel that increased application of pesticides improve yields. The slightly lower level of statistical significance for pesticide use reduction in the basic model compared to the other attributes can likely, in part, be explained by the fact that it is picking up these countervailing preferences in the overall sample.

Table 3. *Multinomial Logit Model Estimation Results*

Parameter Estimates	Basic Model	w/Interactions with …					Full Model
		Training	Health Impacts	Yield Boost	High & Low Pesticide Expenditures		
Basic Attributes							
Status Quo Dummy	0.498 ***	0.500 ***	0.504 ***	0.477 ***	0.504 ***		0.488 ***
	(0.102)	*(0.102)*	*(0.102)*	*(0.102)*	*(0.102)*		*(0.102)*
Contract Length (years)	-0.107 ***	-0.116 ***	-0.078 ***	-0.108 ***	-0.124 ***		-0.009 ***
	(0.007)	*(0.008)*	*(0.01)*	*(0.01)*	*(0.013)*		*(0.01)*
Release Option	0.333 ***	0.296 ***	0.288 ***	0.472 ***	0.447 ***		0.505 ***
(1=can leave without penalty)	*(0.054)*	*(0.06)*	*(0.075)*	*(0.071)*	*(0.093)*		*(0.079)*
Land Area Enrolled (mu)[1]	0.003 ***	0.003 ***	0.003 ***	0.005 ***	0.004 ***		0.005 ***
	(0.001)	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*		*(0.001)*
Pesticide Use Reduction	-0.006 **	-0.003	-0.010 ***	0.000	-0.011 **		-0.004
(% of 2011 pesticide use)	*(0.003)*	*(0.003)*	*(0.004)*	*(0.004)*	*(0.005)*		*(0.004)*
Cash Subsidy	0.007 ***	0.007 ***	0.007 ***	0.006 ***	0.008 ***		0.008 ***
	(0.001)	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*		*(0.001)*
Interaction Terms					*High Expendit.*	*Low Expendit.*	
x Contract Length		0.048 ***	-0.061 ***	-0.004	0.022	0.027	
		(0.018)	*(0.015)*	*(0.015)*	*(0.018)*	*(0.018)*	
x Release Option		0.168	0.104	-0.305 ***	-0.244 *	-0.073	
		(0.133)	*(0.104)*	*(0.105)*	*(0.128)*	*(0.128)*	
x Land Area Enrolled		0.002	0.001	-0.003 **	0.000	-0.001	
		(0.002)	*(0.001)*	*(0.001)*	*(0.002)*	*(0.002)*	
x Pesticide Use Reduction		-0.019 ***	0.010 *	-0.012 **	0.009	0.006	
		(0.007)	*(0.005)*	*(0.005)*	*(0.006)*	*(0.006)*	
x Cash Subsidy		0.000	0.000	0.002	-0.003 **	0.000	
		(0.002)	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	
Training x Contract Length							0.061 ***
							(0.017)
Health Impacts x Contract Length							-0.062 ***
							(0.014)
Yield Boost x Release Option							-0.266 **
							(0.103)
Yield Boost x Land Area							-0.00272 **
							(0.001)
Training x Pesticide Use Reduction							-0.015 **
							(0.006)
Health Impacts x Pesticide Use Reduction							0.010 **
							(0.004)
Yield Boost x Pesticide Use Reduction							-0.0097 *
							(0.005)
High Pesticide Expenditures x Release Option							-0.140
							(0.105)
High Pesticide Expenditures x Cash Subsidy							-0.003 **
							(0.001)
Log-Likelihood Function	-2988.56	-2979.66	-2977.87	-2968.94	-2978.89		-2947.29

***,**,* ==> Significant at the 1%, 5%, and 10% level, respectively. Standard Errors in Parentheses; 1. One mu ≈ 1/15 ha.

Results of the error components model are presented in Table 4. Through a similar process, interaction terms found to be statistically significant were selected for inclusion in the full model, with focus on the attributes-only and the full model as a comparison with the MNL estimates. As expected, the fit to the data of the error components models is much higher, as demonstrated by the jump in the simulated log-likelihood function values. It is interesting to note the large improvement in model fit produced by the addition of the single panel error component, which once fitted to the model changes the sign of the status quo coefficient, with little effect in terms of the sign and magnitude of the other utility coefficients. This indicates that while the status-quo alternative is indeed treated by respondents as systematically different from the designed alternatives – seen in the high statistical significance of both the indicator variable for the "opt-out" alternative and in the standard deviation for the error component – estimated household preferences for designed alternatives are robust across specifications. This accords with expectations, since the choice experiment questions are regarding an aspect of agricultural production households are thoroughly familiar with, and the consequentiality of the scenario is believable; the government has numerous subsidy policies targeting agriculture.

Table 4. *MNL Model with Error Components*

Parameter Estimates	MNL + Error Components					
	Basic			with Interactions		
Attributes						
Status Quo Dummy	-4.534	***	*(1.144)*	-4.494	***	*(1.152)*
Contract Length	-0.109	***	*(0.004)*	-0.088	***	*(0.006)*
Release Option	0.378	***	*(0.040)*	0.511	***	*(0.062)*
Land Area Enrolled	0.003	***	*(0.001)*	0.004	***	*(0.001)*
Pesticide Use Reduction	-0.005	**	*(0.002)*	-0.007		*(0.005)*
Cash Subsidy	0.008	***	*(0.0005)*	0.009	***	*(0.001)*
Interaction Terms						
Training x Pesticide Use Reduction				0.064	***	*(0.001)*
Training x Contract Length				-0.069	***	*(0.009)*
Health Impacts x Contract Length				-0.145	*	*(0.085)*
Yield Boost x Release Option				-0.001		*(0.001)*
Training x Pesticide Use Reduction				-0.013	*	*(0.007)*
Health Impact x Pesticide Use Reduction				0.009	**	*(0.005)*

Yield Boost x Pesticide Use Reduction			-0.001	*(0.005)*
High Pesticide Expenditures x Release Option			-0.187 **	*(0.001)*
High Pesticide Expenditures x Cash Subsidy			-0.005 ***	*(0.001)*
Error Component St. Dev	11.936 ***	*(1.686)*	11.882 ***	*(1.702)*
Log-Likelihood Function	-2043.92		-2019.80	
McFadden Pseudo R^2	0.360		0.368	

***,**,* ==> Significant at the 1%, 5%, and 10% level. Standard Errors in Parentheses.

Table 5 below presents the estimates of marginal willingness-to-accept-payment (WTA) produced from the full multinomial logit model with error components. In general, results accord with expectations. Households need to be paid (i.e. have a positive WTA of) between CNY 2.64 to CNY 19.14 per mou (the mou is a common unit of land area, equivalent to 0.165 acre, or 0.06665 ha) per year more to increase the contract length by one year. They are willing to reduce payments by (i.e. have a negative WAP of) between CNY 39.49 to CNY 70.31 per mou per year if they are given the option to exit the program without penalty. They are also willing to reduce payments by between CNY 0.34 to CNY 0.82 per mou per year for each 1% increase in share of household land area enrolled, while willingness to accept payment for each 1% increase in targeted pesticide use reduction depends on household type, with this ranging from CNY 0.84-2.16 per mou per year (CNY 5.10-13.10 per acre or CNY 12.60-32.41 per ha).[27]

Table 5. *Marginal Willingness to Accept Payment (WAP) Estimates from MNL+ Error Components Model with Interactions (CNY/mu/year)*

Contract Attributes		Average Effect	By Household Type: Training = 1	Health Impacts = 1	Yield Boost = 1	High Pesticide Expenditures = 1
Per Increased Year of Contract Length	WAP *(95% CI)*	9.53*** *(7.81, 11.25)*	2.64*** *(0.67, 4.61)*	16.96*** *(14.33, 19.59)*		19.14*** *(11.33, 26.96)*
For the Option to Leave the Program without Penalty	WAP *(95% CI)*	-55.17*** *(-69.63, -40.72)*			-39.49*** *(-54.89, -24.08)*	-70.31*** *(-110.99, -29.63)*
For 1% Increase in Land Area Enrolled	WAP *(95% CI)*	-0.41*** *(-0.59, -0.22)*			-0.34*** *(-0.56, -0.11)*	-0.82*** *(-1.3, -0.34)*

[27] Statistically insignificant WAP estimates are not included in these quoted ranges.

For 1% Increase in Targeted Pesticide Use Reduction Compared to 2011	WAP *(95% CI)*	0.76 *(-0.2, 1.73)*	2.16*** *(0.62, 3.7)*	-0.24 *(-1.07, 0.59)*	0.84* *(-0.07, 1.75)*	1.54 *(-0.53, 3.6)*

***,**,* ➔ Significance at the 1%, 0.5% and 0.1% level. WAP is in CNY/mu/year.

5. POLICY SIMULATIONS

Based on the parameter estimates from the full multinomial logit model with error components, Table 6 presents six contract scenarios and the minimum annual eco-compensation rate per mu needed with each contract configuration in order for the model to predict that 100% of the households in the sample would enroll. Out of numerous different contract configurations examined, six scenarios were selected that could realistically be implemented given the context, serve to highlight key findings, and that provide a range of predicted minimum subsidy rates for 100% enrollment.[28] Scenario A was selected as a type of baseline, for example, since for this the model predicts 100% enrollment with a subsidy rate of 0. Also of interest was examination of how total land area enrolled and having a release option impacted the subsidy rate/predicted enrollment relationship. As per the WAP estimates, households preferred contracts offering the option to leave the program without a penalty, with shorter contract lengths, and the enrollment of a larger share of household land, while the pesticide reduction target was in general less important. Households also preferred higher subsidy rates, as would be expected.

Table 6**.** *Policy Simulations Based on Choice Experiment Model Results*

Contract Details	Contract Scenarios					
	A	B	C	D	E	F
Contract Length	2 years	2 years	2 years	6 years	6 years	6 years

[28] Given that the proposed program would be a pilot, too long or extremely short contract lengths were ruled out to keep the scenarios realistic and meaningful. Total pesticide use reduction was also kept within what was considered realistic limits.

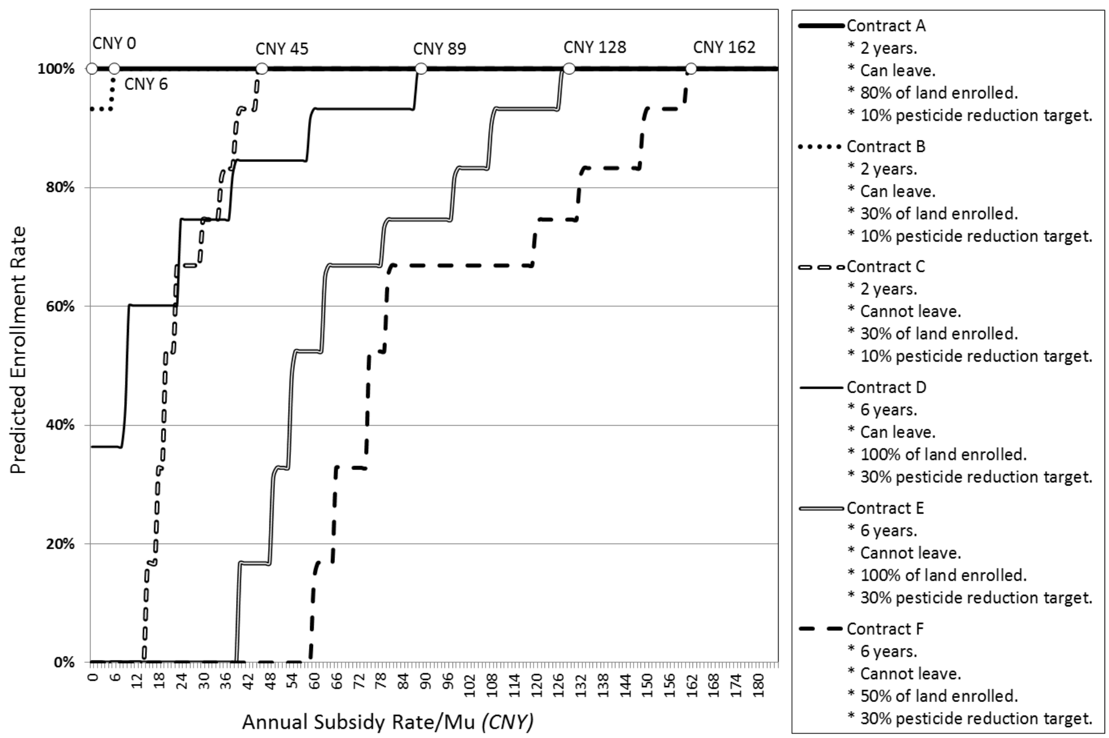
Release Option	Can Leave	Can Leave	Cannot Leave	Can Leave	Cannot Leave	Cannot Leave
Required Household Land Enrollment	80%	30%	30%	100%	100%	50%
Pesticide Reduction Target	10%	10%	10%	30%	30%	30%
Minimum Annual Subsidy Rate for 100% Enrollment (CNY/mu/year)	*0*	*6*	*45*	*89*	*128*	*162*
Average Annual Subsidy Payments per Household at Minimum Rate	0	27	205	1,351	1,944	1,230

A couple of results are of particular interest. First, giving households the ability to leave the program without penalty offers significant predicted savings in total program costs. This result is similar to that of Christensen *et al*. (2011), which find that farmers value flexibility in contract arrangements. For example, contracts B and C are identical except that households cannot leave the program without penalty in C. As a result, estimated average annual cost per household is CNY 178/household higher for C than B (an increase in the minimum subsidy of rate/mu/year of CNY 39). When the other contract characteristics are increased, as in scenarios D and E, this difference becomes even more pronounced, whereby contract E (cannot leave) is estimated to cost on average CNY 583/household/year more than contract D (can leave).

Second, increasing the total amount of household land enrolled reduces predicted minimal costs per unit land area. Estimated minimum costs per mu for contract A (80% of household land enrolled) are CNY 6 less than contract B (30% of household land enrolled, with all other contract details the same). With longer contract lengths and larger targeted reductions, this difference increases, with contract E (100% of household land enrolled) CNY 34/mu less than contract F (50% of household land enrolled, all other contract details the same). Insofar as this sample is sufficiently representatives of rural communities in this region, these results suggests that any future eco-compensation policy targeting rural land-use in Yancheng will be most cost-effective if households are given autonomy in participation choice, and if the program targets a larger share of total household land for enrollment. Note also that initial, shorter, contract lengths are preferred by farming households, as reflected in lower required annual payments. This might be due to concerns about program risks, and/or to anticipated future increases in the opportunity costs of land.

Finally, model results suggest that many cost-effective contract options exist, especially if 100% enrollment is not a strict goal. As seen in Figure 4 – which tracks model-predicted enrollment rates for a range of subsidy rates – 100%, 93.25% and 36.33% of sample households are predicted to be willing to enroll in contracts A, B and D, respectively, without the need for subsidy payments. This indicates that simply providing farming communities with technical support and training in proper pesticide use and in how to reduce health impacts could be sufficient compensation for many households under these different contract scenarios.

Figure 5. *Predicted Enrollment Rates for Different Contract Configurations*



6. CONCLUSION

Results from the survey data analysis find that low-cost opportunities exist to mitigate the impacts of regional agriculture on the Jiangsu-Yancheng wetlands. Households were found to have minimal to no training in pesticide application, with most respondents expressing interest in receiving training and technical support to lower costs, improve agricultural productivity, and minimize impacts on household health. Targeting improved pesticide use is thus confirmed to be a potentially valuable entry point for more in-depth and constructive engagement with these communities. We also find that significant program cost savings could be achieved if households are given autonomy in program participation choice. This is of particular relevance for China, where national programs that target rural sector environmental outcomes are ostensibly voluntary and are often implemented locally in a top-down, non-consultative fashion, to the detriment of program outcomes (Bennett, 2008; Xu *et al*., 2010).

Demonstrating potential cost savings is important for convincing local authorities of the merits of consultative approaches to rural program design and implementation. Internationally, the importance of participatory and adaptive processes has been highlighted in the literature on biosphere reserves (Heinen, 1996; UNESCO, 1996; Schneider & Burnett, 2000). Many agri-environmental programs have climate resiliency as a target, with the establishment of stakeholder participation and social learning mechanisms an important requisite for success (Hulburt, 2015). In a survey of 146 biosphere reserves across 55 countries, Schultz *et al.* (2011) find that stakeholder participation and adaptive co-management practices are linked to higher effectiveness in achieving sustainable development goals, with no adverse impact to biodiversity conservation.

Coastal wetlands are critical for the long-term viability of the world's coastal communities in face of climate change. Costanza *et al.* (2008) estimates that they provide US$23.2 billion/year in storm protection services for the US alone. Tidal marshes and mangroves are estimated to provide 20% of annual ecosystem service values globally despite comprising only a small fraction of land area (Costanza *et al.*, 2014). In the case of China, though comprising just 0.6% of national land area, coastal wetlands provide ecosystem services valued at US$200 billion each year by some estimates, or 16% of total ecosystem services values in China (Paulson Institute, 2015).[29]

The Chinese government recognizes the importance of conserving the country's remaining wetlands. It has been significantly strengthening regulations governing their management and protection, stipulating that wetland area in the country will not be allowed to decrease below a "Red Line" of 53.33 million ha, and has increased investment in restoring degraded wetlands and constructing artificial wetland area (CCCPC and the State Council, 2015). The government is also strengthening its pesticide

[29] Key services provided include nutrient cycling, carbon storage, water purification, absorption of pollutants, the provision of spawning and nursery grounds for many fish species and organisms that maintain marine ecosystem health, and the provision of important habitat for a range of terrestrial organisms, including wintering grounds for a range of migratory waterfowl.

management regulations to ensure that only approved, low-toxicity pesticides are provided on the market, and to strengthen the training and technical support provided to farmers (USDA-FAS, 2017). These measures are encouraging, but effective management on the ground will depend on several factors, not least of which will be the development of effective modes of engagement with the rural communities that interact with these ecosystems. Similarly, while China's policy environment is increasingly supportive of sustainable agriculture, government policies and measures could be strengthened by information feedbacks on the effects of program design and implementation by giving farmers greater voice in decision-making processes governing research and extension (Wilkes & Zhang, 2016).

Choice experiments can be a valuable tool for achieving this goal, as an effective methodology for assessing community and household preferences for program design. Households in our sample responded well to the choice experiment exercise, with the results allowing for initial identification of cost-effective contract design for an agri-environmental scheme targeting pesticide use. This work also provides insights for direct-subsidy approaches to address agricultural non-point source pollution from smallholder agriculture, which according to recent censuses of pollution sources has surpassed industrial point-source pollution as China's main source of water pollution (Xu & Berck, 2014).

This work also highlights the value of choice experiments as a community engagement tool, in this case serving as an initial consultation on a topic of common concern that is envisioned to lead to a more comprehensive series of dialogues and collaboration on a broader range of conservation and regional development issues. The need for this is evident from survey responses: most households had little awareness of the function and importance of the coastal wetlands complex and the JYNNR, much less the impacts their agricultural practices could be having on wetlands ecology, bird populations, and water resources. Weak awareness of the ecological value and social benefits of wetlands was one of four major threats to China's wetlands identified in the government's National Wetlands Protection

Program of Action (2004-2030) and the National Wetland Protection Program Implementation Plan (2005-2010) (ADB, 2011).

Globally, though multi-stakeholder management is a core principal for biosphere reserves, many in developing countries struggle to effectively develop management structures that incorporate the objectives of various interest groups (UNESCO, 2010). Well-developed social institutions have been identified as important for the capacity of country's to adapt to climate change. Inadequate institutional support is frequently cited in the literature as a hindrance to adaptation (IPCC, 2001).

Co-management mechanisms, facilitated by "eco-compensation" interventions, could do much to change perceptions and mitigate conflicts. Numerous households in the sample, especially those inside the reserve, had very strong views about the adverse impacts that the nearby reserve was having on their livelihoods, especially regarding bird-related crop damage. However, the survey data on household agricultural production does not support these perceptions. Per unit area damages from other natural disasters such as flooding and drought were significantly larger, and affected many more plantings than bird-related damage. This suggests that perceptions regarding damage, and who are the "victim" and "perpetrator", play a more important role than actual impacts.

Table 7. *Average Crop Losses Due to Natural Disasters in Sample* *Unit: CNY*

Source of Crop Damage	*Sole or joint source of damage?**	Average Losses / mu**		# of Plantings Affected***	
		2008	2011	2008	2011
BIRDS	*Sole*	-279.16	-244.15	12	26
	Joint	-422.82	-560.94	27	49
PESTS/ DISEASE	*Sole*	-404.43	-339.97	23	57
	Joint	-240.44	-311.09	28	38
DEER	*Joint*	-293.08	-262.61	7	7
FLOODS	*Sole*	-329.26	-471.55	190	634
DROUGHT	*Sole*	-407.72	-325.20	70	144

*Joint source of damage means more than one disaster affected the plot, and thus damages are not solely attributable to the source in question. / **1 mu≈1/15 ha. Averages are across plots affected by the disaster in question. / *** One season's crop on one plot.

Finally, an important issue not addressed in this work is the value of developing a regional framework for improving pesticide use, towards which this choice experiment exercise can be viewed as a first step. Survey results suggest that pest populations are becoming increasingly pesticide-resistant due to what is likely a regional failure in collective action needed to manage a public good (Pingali & Gerpacio, 1997). Improving regional pesticide use to better manage pest populations could – via boosting regional agricultural productivity and reducing the impacts of chemical inputs on ecosystems, human health and water resources – do much to achieve the joint goals of improved conservation, rural livelihood improvement and regional development.

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APPENDIX I – CHOICE EXPERIMENT SCENARIO

Scenario

Misapplication and overuse of pesticides in agriculture can cause serious ground- and surface-water pollution, can adversely impact rural household health due to insufficient protection during pesticide application in fields, and can damage and unbalance the regional ecology by harming important bird and animal species, by killing off natural predators of pests, and by creating outbreaks of pesticide-resistant populations of pests.

In order to address these issues in Yancheng, and to protect the Red-Crowned Crane and other important and endangered bird species in the nearby Jiangsu-Yancheng Wetlands Rare Birds National Nature Reserve, the government plans to launch a 10-year program, to guide farmers on how to reduce pesticide use or shift to lower-toxicity pesticides. This project is voluntary, and may provide the following services:

(1) Provide technical support, training and information to households on:
   a. How to better time and implement pesticide application so as to reduce overall pesticide use while maintaining yields;
   b. How to protect against the potential health hazards to farmers when applying pesticides on their crops;
   c. What options exist for adopting more environmentally-friendly, low-toxicity pesticides.

(2) A cash subsidy.

Farmers participating in the program will be required to reduce pesticide use by a targeted amount for cotton and grain crops during the duration of the program.

In order to ensure that this program will be effectively designed to encourage reduced use of pesticides and the adoption of lower-toxicity pesticides, the government and the Asian Development Bank has arranged for a team of researchers to visit a number of villages inside and nearby the Jiangsu-Yancheng Wetlands Rare Birds National Nature Reserve, including your village, to solicit household views and opinions regarding how such a program could best be designed.

In order to identify what program characteristics you and other households like you would most prefer, we would like to ask you to make 8 different comparative choices. Each choice is independent, and will involve choosing which of three different possible program designs you would most prefer, or whether you would prefer none of these. While these are simply a selection of possible program designs, please make these choices thinking about what you would realistically be interested in and would be able to participate in. This will ensure that we are able to accurately gauge your preferred policy choices.

Enumerators: Give households this card to look at, and make clear to them each of the contract terms.

The terms of the contract involve the following five aspects:

1) Contract Length

- There are **three** types: 1 year, 5 years, 10 years.

2) Program Exit Option

There are **two** types: Cannot leave the program; Can leave the program with no penalty.

3) Land Area Coverage (The % of your land that is enrolled in the program)

There are **three** levels: 20%, 50% 100%

4) Pesticide Use

There are **four** types of conditions:
With guidance, during the contract period farmers reduce annual pesticide use by 5% in comparison to 2011.
With guidance, during the contract period farmers reduce annual pesticide use by 10% in comparison to 2011.
With guidance, during the contract period farmers reduce annual pesticide use by 20% in comparison to 2011.
With guidance, during the contract period farmers reduce annual pesticide use by 30% in comparison to 2011.

5) Cash Subsidy

There are **four** levels: CNY 10/mu, CNY 50/mu, CNY 80/mu, CNY 120/mu

APPENDIX II – SURVEY SAMPLE DESCRIPTIVE STATISTICS

Table A-1. *Survey Sample Household Characteristics, 2011*

Household Characteristics	Mean	*St. Dev*	Median	Min	Max
Population	3.45	*1.41*	3	1	9
…of this, Male.	1.75	*0.80*	2	0	4
Share of Households Classified as "Agricultural"			95.2%		
Maximum Member Years of Education	9.84	*3.90*	9.5	0	18
Average Member Years of Education	6.67	*3.07*	7	0	16
Average Age	44.43	*12.61*	41	21.25	80.5
Household Head Years of Education	7.22	*3.52*	8.5	0	16
Household Head Age	52.68	*9.96*	52	0	81
Share of Household Heads that are Male			95.5%		
Number of Working-Age Adult	2.75	*1.14*	3	0	7
Total Days Worked in Agriculture	386.84	*216.34*	360	0	1800
Total Days Worked Off-farm	275.23	*265.74*	250	0	1420
Number of Household Plots	3.61	*1.51*	4	1	8
Household Per Capita Land (mu)	4.96	*4.56*	3.5	0.04	32.62