Willingness to pay for bundled agricultural insurance products – results from a discrete choice experiment in Bihar, India

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1. Introduction

Agriculture in India is an inherently risky occupation for farmers who are constantly faced with production shocks, especially, from natural disasters like flood and drought. Given that Indian farmers are mostly smallholders, with very few resources, agricultural risk management becomes of paramount importance. Production shocks can contribute to chronic poverty when assets are damaged and agricultural yields are low (Clarke, Nicola, Hill, Kumar, & Mehta, 2015). But disaster risks are increasingly unavoidable, at least in the near term with climate change. Risk management has become an important dimension of climate change adaptation and crop insurance is an important component of risk transfer mechanism. But in less developed countries where the insurance market is not mature, has hindered the uptake of insurance amongst farmers (Aryal et al., 2020). Farmers without insurance would find it difficult to recover from climatic shocks, repay loans, and adapt to new technology as necessitated by climate change (Panda et al., 2013).

In India, the first crop insurance scheme was launched in 1972 with cotton farmers in Gujarat, that was extended to cash crop farmers in six states. The Pilot Crop Insurance Scheme (PCIS) in 1979, that followed it, also covered cereals and oilseeds, and extended to 13 states. PCIS continued till 1984-85, as it was replaced by the Comprehensive Crop Insurance Scheme (CCIS) in Kharif, 1985. CCIS was launched in 15 states on an area-based approach and covered cereals, pulses, and oilseeds. It was also linked to crop loan schemes as compulsory. Highly subsidized premiums and high claim-to-premium ratios made the scheme financially unviable, and it was replaced by the National Agricultural Insurance Scheme (NAIS) in 1999, which was further changed into Modified-NAIS in 2010-11. Year 2007 also saw the launch of Weather based crop insurance schemes (WBCIS) in Karnataka. WBCIS was also unique as it allowed private companies to enter the crop insurance market and compete with the public insurer (Clarke et al., 2012). Despite these efforts, crop-insurance had very little penetration in the agricultural sector (only 23.8% of Kharif cultivated area in 2014); as it suffered from high premiums, delay in settlements and discrepancy in area calculations (Ashok Gulati; et al., 2018).

All these different schemes culminated in the launch of Pradhan Mantri Fasal Bima Yojna (PMFBY) in 2016. It continued with the area-based approach and brought both indemnity-based and index-based insurance under the same umbrella. Under PMFBY, farmers need to pay only 2% premium for Kharif crops, 1.5 percent premium for Rabi crops and 5% for commercial crops. The rest of the premium is subsidised and shared equally between the state and the centre. PMFBY was mandatory for loanee farmers till this was relaxed in Kharif 2020 (Tiwari et al., 2020). Despite these efforts, coverage of crop insurance continued to remain low – only 30% of cropped area and 19% farmers (again mostly loanee farmers) are insured under PMFBY. Because of the subsidy burden State governments are also unwilling to continue with the PMFBY scheme, for example, in Bihar the PMFBY scheme was discontinued and instead another scheme was launched known as Fasal Sahyata Yojana. Recently Central Government also has capped its contribution up to maximum 30% premium, in an effort to discourage very high premium rates. Indemnity based insurances which currently dominate in India suffer from high premiums & non-payment/delayed payment of claims. For promotion of crop insurance, there is an urgent need for design of crop insurance schemes with more accurate and quicker settlements, and here index-based insurance products hold promise (Matsuda & Kurosaki, 2019).

There is also a growing interest in understanding whether bundling crop insurance with other risk mitigating technologies like credit, certified seeds or stress tolerant seeds would encourage farmers to take up insurance or reduce its demand (Bulte et al., 2020; Giné & Yang, 2009; Mor & Syll, 2019; Ward et al., 2019). There is some theoretical reason that we discuss in the next section explain why bundling might crowd-in investments rather than crowd-out but there is need to pilot and test empirically the effectiveness of such bundled products in different contexts and different products.

In this study we examine the potential of combining index insurance with other risk management strategies, through a discreet choice experiment with farmers in the flood-prone pilot districts of Bihar, India. We estimate farmer's willingness to pay for these different risk management strategies and ascertain if there are complementarities between these different tools.

2. Role of crop-insurance and other risk management options

Crop insurance can be categorized into two major groups: Indemnity-based insurance and the Index-based insurance. Indemnity based insurance products, which are also referred to as traditional insurance, determine claim payment based on the actual loss incurred by the policy holder. Despite frequently strong theoretical arguments for insurance, attempts to provide formal, indemnity-based crop insurance in many developing countries have struggled, arguably due to poor contract performance, asymmetric information, high transaction costs, and high exposure to covariate risks (Barnett & Mahul, 2007; Carter, Cheng, & Sarris, 2016).

To overcome the problems associated with the traditional insurance products, policymakers and development practitioners have turned to 'Index-Based Insurance' (IBI) products (Alderman & Haque, 2007). In IBI products, the pay outs are based on the value of an "index" which are determined by exogenous information, unlike the losses measured in the field in case of traditional insurance. Indexes are variables which are based on weather parameters (however, not limited to) like rainfall, temperature, etc. measured during a pre-specified time at a particular weather station. Index-based insurance products offer several advantages in terms of making the index more transparent to the insured, minimizing asymmetric information between the insured and insurer and reducing the probability of adverse selection and moral hazard (Clarke, Nicola, Hill, Kumar, & Mehta, 2015). However, a major shortcoming of IBI products is the 'basis risk'. Basis risk arises when the index measurements do not match an insured farmer's actual losses as payments are not directly dependent to on-farm performance (Miranda, 1991).

In recent decades, weather-based index insurance has been considered as a valuable alternative for traditional crop insurance in the face of a catastrophic event like drought or flood in developing countries. However, given the innovative potential WII products show, the demand for the same across farming households in developing countries have been typically low (Cole, et al., 2013). This discrepancy between expected and actual demand raises questions concerning the willingness-to-pay for insurance and factors behind their preferences.

Several studies have examined the factors affecting WTP of index insurance uptake to understand the barriers to adoption and other than price of insurance there are other constraints to adoption like lack of trust and financial literacy, liquidity constraints, and salience etc. (Giné, Townsend, & Vickery, 2007; Cole, et al., 2013; Hill, Hoddinott, & Kumar, 2013). Index insurance is a useful financial tool to help farmers cope with the disaster risks, however, there are several reasons why especially poor farmers are unable to get insurance. If a high cash reward prior to purchasing insurance is given, insurance take up increases (Cole, et al., 2013). In an attempt to solve these constraints, several studies have been experimenting with bundled products; wherein, index insurance, a financial tool, is bundled with a complementary technological tool that will help the farmers overcome immediate constraints like limited access to credit, providing improved seed varieties that can withstand the risk, fertilizer and so on.

Lybbert and Bell in their 2010 article (Lybbert & Bell, 2010) argue that stress tolerant seeds can be an effective risk management product, as it works like an insurance by protecting yield in years of natural calamity, by paying a "price" of reduced yield during normal conditions. But more importantly there is complementarity in stress tolerant seed and index insurance because insurance by itself may be too costly if it covers both moderate and severe weather risks. But if stress tolerant seeds are bundled with insurance, then for moderate weather shock events the seed will protect farmer's yield, whereas for severe cases, where even yield for stress tolerant seed is not protected, then insurance will kick in. Since in such a bundled product, insurance will need not cover medium weather risks, the expected pay-out will be much lower. Thus, a bundled insurance could be much more affordable for farmers (Lybbert & Carter, 2014). This can be explained using a toy-example as in Figure-1. Let us assume farmers are using regular paddy varieties that suffer yield reduction after 7 days of continuous submergence and is almost totally damaged after 12 days of submergence. Then a full coverage insurance (orange line in the Figure below) would require compensating the yield loss after 7 days' submergence (moderate flood events), and for events with 12 or more days of submergence (severe flood events) the full loss (say Rs 950 per unit of land) needs to be insured. In comparison if farmers are using stress tolerant variety, then yield loss starts happening only after 12 days' or more of submergence, and full loss happens only for 15 days or more of continuous submergence (i.e., extreme flood events). So, for this farmer, the stress tolerant variety is protecting against moderate flood fully and severe flood partly. Thus, he needs a limited insurance coverage that will protect against severe flood partly and only extreme floods fully.

Since more severe floods are rarer events and thus limited insurance coverage protect against low-probability events, the premiums will be cheaper. The argument here is that stress tolerant seeds are a much cheaper way to protect against moderate floods than insurance.

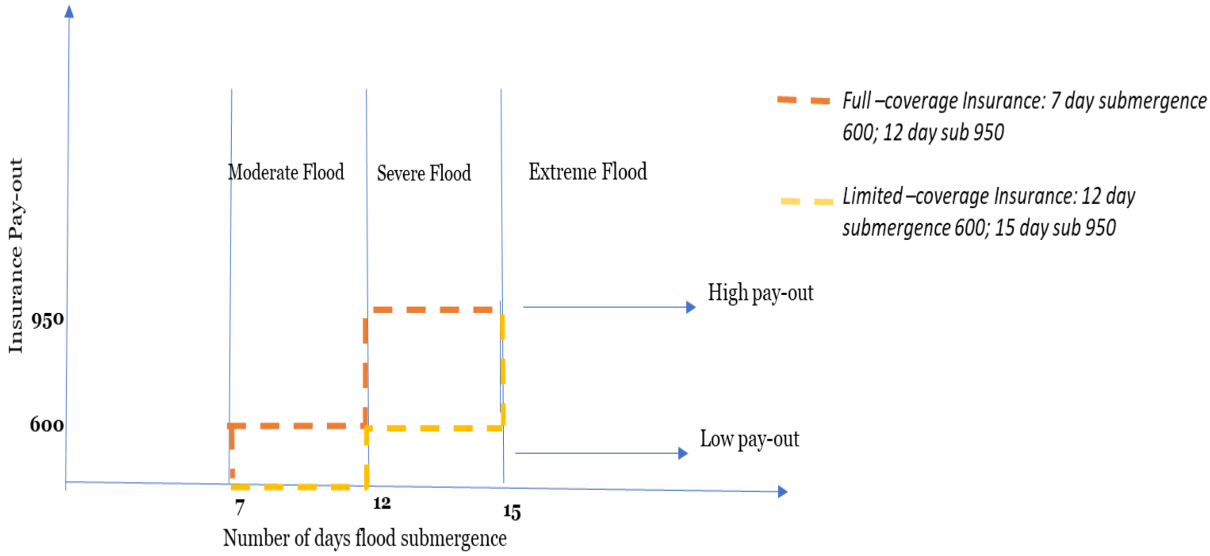

Figure 1 -Full and Limited cover Insurance

Ward and Makhija (2018), explore the demand for such a product, which combines weather index insurance with drought tolerant (DT) rice variety amongst the rain-fed rice producers in Odisha, India. The study used a Discrete Choice Experiment to elicit the farmers' preferences for this bundled product. Their study finds that farmers allocated a higher valuation for the bundled product however, they were also sensitive to basis risk. In another study, Ward et al., (2020) study the demand for a similar bundled product i.e., WII and drought tolerant rice for drought risk in the farmlands of northwest Bangladesh during the monsoon season. They find that the WTP for the DT rice bundled with full-coverage policy was greater than the WTP for a limited coverage policy. In contrast to earlier study, they also find that farmers value the insurance product significantly more than their actuarially fair values.

We follow similar approach to understand the complementarities between flood insurance and flood-tolerant seeds, along with another important risk management product for farmers in flood-prone regions. Often once the flood has happened, it destroys the paddy crop in the field and then once the flood water has receded, it might not be possible to sow paddy again in the same field but there is still sufficient window of time before the Rabi season for cultivation of a short duration crop in the field. If farmers are provided with seeds for alternative crops, it might be possible, to further increase the resilience of farmers. In fact, if the seeds are bundled within the insurance scheme as a payment in kind for flood affected farmers it might be useful for them to tackle flood risk. So, it is important to provide farmers with means to cultivate high-value crops in the field after flood water has receded so that they can earn income through cultivation.

A pilot programme of such a bundled product of different risk management options was launched in 2019, by a development organisation with farmers in the flood affected villages of Bihar. The farmers were provided with insurance, flood tolerant seeds (Swarna Sub-1) and high value vegetable seeds for cultivation post-flood in case flood happens. This was following a prior launch of an index-based flood insurance product in the same region (but not same villages) by the same organisation in 2017 and 2018. after that it has expanded to other regions in India and Bangladesh. In this paper we estimate the willingness-to-pay for these different risk management technologies using a discrete choice experiment.

3. Study Area

Bihar is one of the worst flood-affected states in India, accounting for almost 17% of India's total flood prone area according to one estimate. The rivers flowing through Bihar like Kosi, Bagmati, Gandak etc. originating in Nepal from the Himalayas, bring with them heavy discharge and high sediment load as they descend from the mountains and flows into the plains of Bihar. Heavy rainfall in Nepal during the monsoon causes these rivers to bring immense water into the Bihar floodplain in a short time span, causing very regular floods. They inflict severe damage to agriculture, cattle, houses and to human lives. Fig 1. shows that floods have occurred almost every year in the last 70 years and the extent of damage in the agricultural sector often crossing 1 million hectares of agricultural land. In the last 20 years, the state has witnessed 8 major floods during 2004, 2007, 2008, 2011, 2013, 2016, 2017 and 2019, causing immense loss to human life and livelihood.

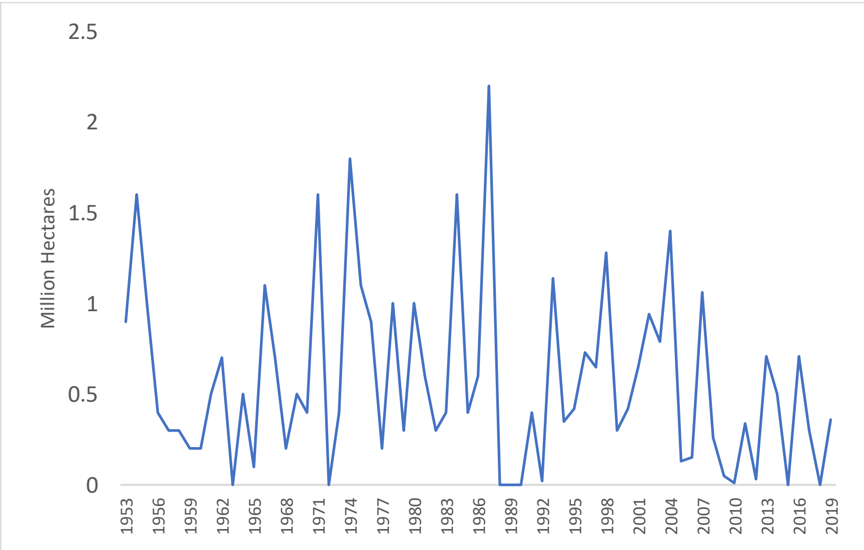

Figure 2 - Agricultural Area damaged by Flood in Bihar

The Bihar State Disaster Management Agency (BSDMA) has categorized the following districts in North and Central Bihar belonging to High or Very High Flood Hazard categories – Darbhanga district as Very High (i.e., Hazard index above 150) and Muzaffarpur, Samastipur, Patna, Khagaria, Katihar, Shamarhi districts as High Hazard category (Hazard index between 100-150). The Bagmati river basin which includes eastern part of Muzzaffarpur district falls under the very High and High flood hazard categories (Fig 2). Accordingly, when piloting these insurance products, villages in the Bagmati river basin were chosen mostly from Katra and Gaighat blocks in Muzaffarpur district, based on a flood hazard classification (High, Medium, and Low) of villages.

For the discreet choice experiment also, we selected villages from Gaighat and Katra block in Bagmati

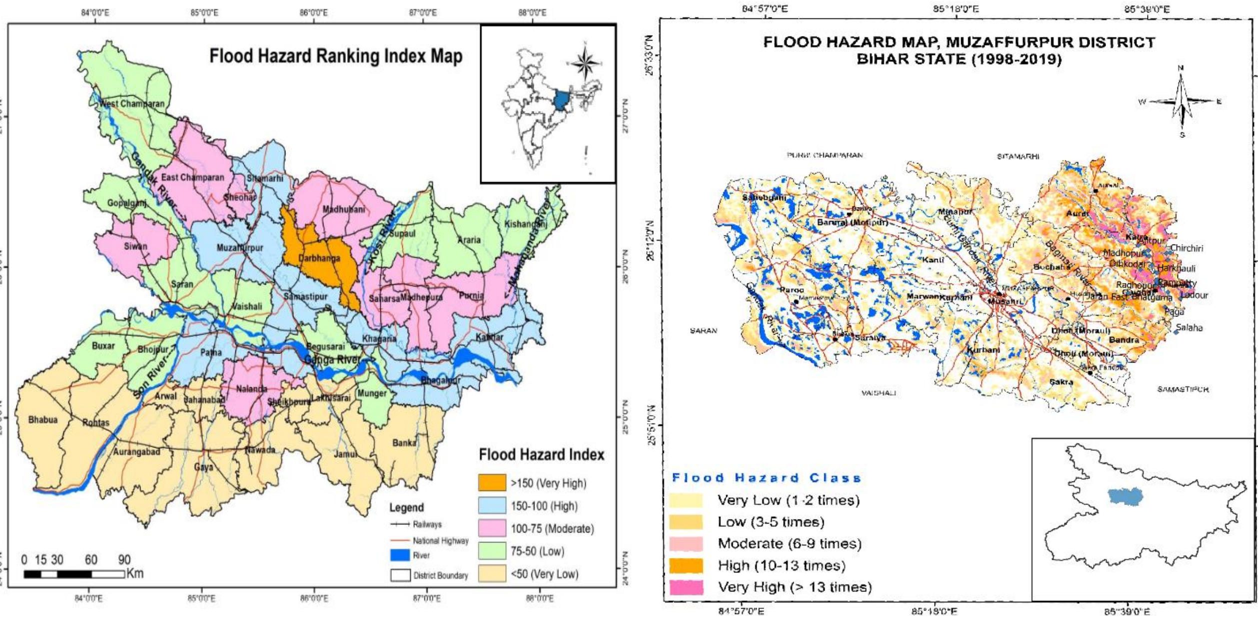

Figure 3 - Flood Hazard Map of Bihar and Muzaffarpur (Source: Flood Hazard Atlas of Bihar, BSDMA)

river basin where the insurance pilots were introduced. We had 3 types of farmers in our sample – farmers who were part of the bundled insurance pilot in 2019, farmers who were part of the index-based flood insurance pilot since 2017 and control farmers from nearby villages, where the pilots were not introduced. “Bundled insurance” farmers paid for a combined product that included flood-tolerant seeds (Swarna Sub-1) and index-based flood insurance, along with post-flood seeds. Index-based insurance pilot farmers on the other hand got the insurance component only. So, they have experience with flood insurance, but they do not have exposure to flood tolerant seeds. Finally, we control farmers had no experience with either index-based flood insurance or flood tolerant seeds previously.

There was a pilot study conducted in 2017 that interviewed farmers in index-based flood insurance pilot and control farmers from nearby villages. Our sample of index-based flood insurance farmers and control farmers were selected randomly from the households that were interviewed in the pilot study. Whereas, for selecting our sample of “bundled insurance” farmers we selected randomly from the list of beneficiaries under the pilot. For our purpose we removed villages that had less than 8 beneficiaries for logistical reasons and then from the remaining villages selected a random sample of beneficiary farmers proportional to number of beneficiaries in each village i.e., villages with more beneficiaries also had more farmers in our sample. In total we had a total sample of 307 farmers with almost equal number of “bundled insurance” farmers, “index-insurance” farmers and control farmers as shown below. The purpose of selecting all 3 types of farmers was done so that there would be enough variation in our sample with respect to exposure to insurance and stress tolerant seeds. The discreet choice experiment and household survey was conducted in October-November 2019.

Table 1 - Sample selection across villages

Farmer Category	District	Block	Village	Flood Hazard Class	Frequency	Total
Bundled Insurance Pilot Faremrs	Muzaffarpur	Gaighat	Dihkodai	High	11	102
	Muzaffarpur	Gaighat	Jamalpur Koo	High	12	
	Muzaffarpur	Gaighat	Jaran East	High	6	
	Muzaffarpur	Gaighat	Pirochha	Low	12	
	Muzaffarpur	Gaighat	Raghopur	High	8	
	Muzaffarpur	Katra	Barri	High	8	
	Muzaffarpur	Katra	Bhandhpura	High	8	
	Muzaffarpur	Katra	Chirchiri	High	7	
	Muzaffarpur	Katra	Nawada	High	9	
	Muzaffarpur	Katra	Tehwara	High	21	
Control Farmers	Muzaffarpur	Katra	Madhopur	Medium	15	103
	Muzaffarpur	Gaighat	Misraulli	High	25	
	Muzaffarpur	Gaighat	Paga	Medium	20	
	Muzaffarpur	Gaighat	Rampatty	Low	24	
	Samastipur	Kalyanpur[1]	Salaha	Medium	19	
Index Insurance Farmers	Muzaffarpur	Gaighat	Bhatgama	Low	40	102
	Muzaffarpur	Gaighat	Gangia	Low	13	
	Muzaffarpur	Gaighat	Harkhauli	Medium	13	
	Muzaffarpur	Gaighat	Ladour	High	16	
	Muzaffarpur	Katra	Ajitpur	Low	12	
	Muzaffarpur	Katra	Andama	Low	8	

4. DCE Design

Willingness to pay (WTP) can be understood as the economic value of a good for an individual and it provides crucial information for assessing economic viability of projects, policy alternatives, financial sustainability and designing socially equitable subsidies (Brookshire & Whittington, 1993). In case of understanding the economic viability of index insurance products, several methods have been developed to measure WTP. Broadly, these methods can be distinguished as stated preference methods (SP) and revealed preference method (RP). The stated preference method includes, choice experiments (conjoint analysis and choice modelling) and Contingent valuation methods (CV), while revealed

[1] This control village is in a different district, but it lies at the border of Muzaffarpur and in the same Bagmati basin which is our focus.

preference methods comprise of hedonic pricing, travel cost method and so on. The SP methods utilize field survey and experiment in eliciting the insurance demand. The most common approach adopted in recent empirical studies on index insurance is the Contingent Valuation (CV) method in which survey questions elicit respondents WTP. Another approach under the SP method is Choice modelling which allows the researcher to estimate marginal values for various attributes embodied in different goods and services, including non-market goods/services. Choice experiments have become an increasingly important mode of studying economic behaviour and demand pattern.

Choice experiments theoretically or empirically model choices made by people among a finite set of alternatives. The models then statistically relate the choice made by each person to the attributes of the person and the attributes of the alternatives available to the person. Choice experiments are useful as they elicit valuations for a series of attributes bundled into a good and results of which can be used to estimate welfare changes (Hanley, Mourato, & Wright, 2001).

For this discreet choice experiment, we had 5 attributes, where 2 attributes have 2 levels, 1 attribute had 5 levels and the other 2 attributes had 4 levels each. So, the full-factorial design matrix will have (2 * 2 * 5 * 4 * 4 =) 320 alternatives which can be combined into 51040 pairs, which is practically not feasible to implement. Instead, we develop a fractional factorial D-efficient design using the modified Fedorov algorithm with the help of the user-written dcreate command in STATA (Hole, 2015). In such a D-efficient design the choice-sets are chosen to minimise the weighted determinant of the variance – covariance matrix of estimated coefficients for a given prior for those coefficients. It ensures more precise estimates of the coefficients.

For the design we chose to have 30 choice sets in total with 2 alternatives along with 1 opt-out option in each choice set. To minimise respondent fatigue, we divided the design into 3 blocks so that each respondent will only respond to 10 choice sets. There were no choice sets where 1 alternative clearly dominates 2nd alternative (primarily because of the attribute "insurance provider" which is a categorical variable, and it is non-overlapping in all choice sets). There was one additional choice card that had a clear dominated choice. This was used for consistency check. We drop individuals making a dominated choice, but the results hold even if we drop individuals choosing the dominated alternative in this choice card. This card was not used in our choice estimates. The final design had D-efficiency of 2.25.

The rationale for choosing the attribute levels for this discreet choice experiment are discussed in Annexure 1, to approximate real world values of yield gain from stress tolerant seeds in submergence condition and yield penalty in normal conditions against HYV seeds. The coverage and trigger points under limited and full insurance products are similarly approximations of agricultural loss under different flood conditions. The choice-sets were unlabelled as no mention of seed variety or insurance company were mentioned. Also, all the attribute levels are for a reference plot of 1 Katha (i.e., 4.5 decimals). Annexure 2 includes an example choice card used in our experiment.

Table 2 - Attribute table for the Discreet Choice Experiment

Attribute	Level
Paddy seed type (2 Levels)	• Submergence Tolerance (***Yield profile:*** *no submergence =83 Kg/Katha; 1-7 days = 68 Kg/Katha; 8-14 days=53 Kg/Katha; >15=6 Kg/* Katha[2]*)* • Non-Submergence tolerance (***Yield profile:*** *no submergence =100 Kg/Katha; 1-7 days = 55 Kg/Katha; 8-14 days=28 Kg/Katha; >15=6 Kg/Katha)*
Index Insurance (4 Levels)	• Full-cover low pay-out *(600 Rs after 7-day continuous flood submergence)* • Full-cover high pay-out *(950 Rs after 12-day continuous flood submergence)* • Limited-cover low pay-out *(600 Rs after 12-day continuous flood submergence)* • Limited-cover high pay-out (*950 Rs after 15-day continuous flood submergence)*
Post Flood seed for vegetables (2 LEVELS)	• Yes or No
Price (Rs.) (4 LEVEL)	• 10, 40, 70, 110
Insurance Provider (5 LEVELS)	• Central Government • State Government • Private Company • Micro Credit Provider • Local Cooperative

5. Econometric method

We use the random utility framework (Ben-Akiva & Lerman, 1985) to model farmers' preferences, where $U_{ni} = V_{ni} + \varepsilon_{ni}$ gives the utility of decision-maker n for choosing alternative i. V_{ni} is the deterministic part and ε_{ni} is the unobservable random error term. V_{ni} is a linear function of the observable attributes (x_{ni}) of the alternative i as faced by decision-maker n. Hence the probability that decision-maker n chooses alternative i among J alternatives is given by $P_{ni} = \Pr(U_{ni} > U_{nj}) = \Pr(x_{ni}\beta + \varepsilon_{nj} > x_{ni}\beta + \varepsilon_{nj})\,\forall\, j \neq i$; where β is the coefficient vector (McFadden, 1974). To generate the closed form solution of this probability function we assume the error terms as i.i.d Type 1 extreme value (Gumbel) distribution and get $P_{ni} = \frac{\exp(x_{ni}\beta)}{\sum_{j=1}^{J}\exp(x_{nj}\beta)}$. The coefficient vector β is then estimated through Maximum Likelihood procedure. This is the standard conditional logit model. This

[2] 22 Kathas=1 acre, i.e., 1 Katha = 4.5 Decimal. KATHA is the unit farmers understand easily.

model has two important limitations, firstly the coefficient vector β is assumed to be same for all decision-makers. Secondly, the assumptions imply independence of irrelevant alternatives i.e., the preference between any two alternatives (relative probabilities) is not affected by other alternatives in the choice set.

Both are rather restrictive assumptions and the random parameter logit model (Train, 2003) relaxes those restrictive assumptions, by allowing the coefficient (β) to vary for each decision-maker in the population. Coefficient (β) is assumed to be drawn from a density function and we estimate the parameters of this density function from the observed choices of our sample decision-makers. In particular the above probability function $becomes\ P_{ni} = \int \frac{\exp(x_{ni}\beta)}{\sum_{j=1}^{J}\exp(x_{nj}\beta)} f(\beta|\theta)d\beta$; where $f(\beta|\theta)$ is the pdf of β; and θ are the distribution parameters that we estimate. In this paper we take $f(\beta|\theta)$ to be normally distributed with uncorrelated coefficients (i.e., the off-diagonal elements of the covariance matrix are zero).

So, our objective is to estimate the mean and standard deviation of the normal distribution. The likelihood function for a group of N decision-makers making T sequence of choices then becomes $\int \prod_{t=1}^{T}\prod_{i=1}^{J}\left[\frac{\exp(x_{nit}\beta)}{\sum_{j=1}^{J}\exp(x_{njt}\beta)}\right]^{y_{nit}} f(\beta|\theta)d\beta$; where y_{nit} is the indicator variable equal to 1 if decision-maker chooses alternative i in choice-set t. This integral does not have a closed form solution and instead replaced with a Monte-Carlo integral. The resultant simulated log-likelihood function is estimated using a Halton sequence of 1000 draws for simulation. We estimate the conditional logit model using cmclogit command and the random parameters model using the user-written mixlogit command in Stata with uncorrelated coefficients (Hole, 2007).

The individual level coefficients are also estimated using the method in Revelt and Train (2000) for the decision makers in our sample. These are defined as the conditional expectation given the response pattern (y_n) and the set of alternatives (x_n) in the sample i.e., $E(\beta|\ y_n, x_n)$. These are estimated with the mixlbeta command after using the mixlogit command in Stata. The individual level coefficients are particularly useful for identifying heterogeneity in the coefficient estimates (Train, 2003).

6. Results

a. Descriptive analysis

The table below gives the socio-economic characteristics of farmers in our sample across different categories. Overall, 39.1% of households had a household head who has passed class 10 or above and it is significantly higher amongst “Bundled Insurance” farmers in our sample (54.9%) vis-à-vis “Index insurance” farmers (40.2%) and control farmers (22.3%). Also control households were significantly more from scheduled caste or a scheduled tribe (35%) as compared to our households from “Bundled

Insurance” pilot (12.8%) and “Index insurance” pilot (11.8%) samples. The average age of our sample households is 52.2 years with an average experience of almost 25.5 years in agriculture. Across sample again we find that household heads from control households were slightly more aged and with more experience in agriculture as compared “Bundled Insurance” or “Index insurance” households, but the difference is only around 4-6 years on average.

Next if we compare the average cultivated area and the average plot size of our farmers, we find that 1.01 ha is the average cultivated area for the full sample and 0.2 ha is the average plot size for these farmers. Although we could not find any significant difference in average plot size amongst our 3 groups of farmers, but control households had significantly lower total cultivated area (0.86 hectare) as compared to “Bundled Insurance” farmers (1.16 hectare) and “Index insurance” farmers (1.02 hectare) households. In terms of susceptibility to flood, we found that while the average distance of agricultural field from the nearest river is 0.76 km, control farmers are significantly nearer to river (0.57 km) as compared to “Index insurance” farmers (0.64 km), while “Bundled Insurance” farmers were the farthest from river (1.06 km). The total yearly income of farmers in our sample was Rs.115382 and we could not find any significant difference across different types of farmers.

Table 3 - Socio-Economic characteristics of sample farmers

	Bundled Insurance farmers (N=102)	Index Insurance farmers (N=102)	Control farmers (N=103)	Stat sig.	Full Sample (N=307)
% of households with household head having passed class 10 and above	54.9	40.2	22.3	****	39.1
% of households belonging to the scheduled caste/ scheduled tribe	12.8	11.8	35.0	****	19.9
Age of household head	51.5^b	49.6^b	55.5^a	**	52.2
Household head's experience in agriculture (years)	24.7^b	23.0^b	28.8^a	***	25.5
Average Cultivated area in Kharif 2019 (in hectare)	1.16^a	1.02^a	0.86^b	*	1.01
Average plot size in Kharif 2019 (in hectare)	0.27	0.16	0.16	n.s.	0.20
Average distance (in km) of agricultural field from nearest river	1.06^a	0.64^c	0.57^b	***	0.76
Total yearly income in Rs.	121407	116178	108626	n.s.	115382

*(**)[***] Statistically significant at the 5% (1%) [0.1%] level of alpha error probability, based on (multiple) Mann-Whitney tests, accounting for family-wise error; diverging superscript letters indicate statistical significance at least at the indicated level.

The primary cropping pattern in this flood affected region of Bihar where our survey was done is the paddy – wheat system. Since the villages are affected by flood every year, paddy production is limited and extremely variable. Consequently, the farmers are dependent on wheat for their livelihood. Our field visits indicated that for all farmers, wheat is the main crop on which their financial security depends. But most of them also sow paddy during kharif season. 97% farmers in our sample have sown paddy in the last Kharif season. During Rabi season along with wheat, some area is dedicated to other crops like Maize, lentil, vegetables etc. Our estimates show that the average cropping intensity is around 184 percent for the farmers in our sample. The reason for is that primarily the during Rabi season almost all cultivatable area is used, and almost all the people sow paddy in their available land during Kharif season, even if there is high probability of flood. Except few very low-lying areas almost all area is sown with paddy.

The most common types of paddy seed used by our sample farmers is 6444, approximately 80% farmers use this variety. Other types of high yielding variety seed used in the area are 27P31 and 28P68. In fact, when we asked which variety farmers think give the highest yield under normal conditions, farmers responded with 6444. The 3 most common reason for choosing 6444 is given as high yield (28%), stable yield (22%) and easy availability (16%). Swarna Sub-1 which is a flood tolerant variety that have proven to give quite stable yield up to 15 days of submergence, but awareness amongst farmers about this variety is quite low. Among the non-"Bundled Insurance" farmers, we asked how many are aware of Swarna –Sub1 variety and only 11% have heard of this variety. Although farmers who have previously used Swarna-sub1 were very few, still it shows that their expected yield under normal conditions is given as 79 kg per Katha, while it is around 62 kgs per Katha till 7 days' continuous submergence, and around 48 kgs till 15 days' submergence and 23 kgs after 15 days' submergence. However, we need to keep in mind that farmers are new to this variety of seed and their expectation is partly formed by their experience with Swarna sub-1 this year, which was an excessive flood year, destroying even Swarna Sub-1 variety. This might have resulted in expected performance of Swarna sub-1 under flood conditions to be worse than what has been tested previously in the field. Some progressive farmers are aware of Swarna sub-1

variety, but they have not used it previously it due to unavailability and lack of awareness. It shows the importance of raising awareness on flood tolerant varieties amongst farmers to facilitate adoption.

b. DCE estimation results

Estimation results from the Conditional Logit model and Random parameters logit (RPL) model are reported in Table 4 below. The coefficient estimates in both the models give qualitatively similar results, but the RPL model allows for heterogeneity in preference amongst respondents and gives a better fit for the data, as evidenced from the lower AIC, BIC values and higher log-likelihood. For the rest of the paper, we discuss the coefficient estimates from the RPL model. The absolute coefficient values in

Table 4, indicates the mean marginal utility (with standard error) of each attribute level of the choice model and it is difficult to directly interpret them. Since here the attributes are dummy-coded, they can show the relative preference for different attribute levels amongst respondents as compared to the base category.

The negative coefficient on price indicates that positive utility for money i.e., more expensive bundles are less preferred as we would expect. The positive and significant coefficient for the non-status quo alternative specific constant (ASC) in Table 4, indicate that there is positive marginal utility derived from the proposed flood insurance schemes as opposed to the status- quo of no- insurance. Only 10% respondents[3] preferred the opt-out option over any form of insurance. Although even the base category of insurance (limited coverage low pay-out option i.e., 600 Rs pay-out after 12 days of submergence) is preferred than no insurance, on average farmers prefer the higher pay-out insurance options (Rs 950 pay-out either after 12 days or 15 days).For the higher pay-out option, farmers on average are willing to pay a premium for the full coverage insurance. Interestingly the coefficient for Full-coverage low pay-out option is not significantly different than the base category i.e., limited coverage low pay-out, indicating that on average there is no extra premium for the low pay-out being paid after 7 days submergence instead of 12 days. The coefficient for flood tolerant seed is insignificant i.e., on average farmers do not have any preference for stress tolerant seeds as compared to non-stress tolerant varieties. It is probably reflecting the fact that stress tolerant seeds protect against moderate flood events but there is a yield penalty in normal conditions as compared to HYV seeds. This is important in the context of adoption of stress tolerant seeds. On average our respondents also prefer post flood seed availability and if the insurance provider is Central Government. There is however substantial heterogeneity in the preference for post-flood seeds, where 37% did not prefer the post-flood seed availability.

[3] Since the RPL model allows for preference heterogeneity, we can estimate the percentage of respondents with negative coefficient as $100 * \Phi(-\frac{b_k}{s_k})$

Table 4 – Coefficient estimates of the choice model

	Conditional Logit Model	Random Parameters Logit	
Parameters	Mean	Mean	SD
Price	-0.013***	-0.015***	
Alternative specific constant – non - status quo	1.139***	1.641****	1.266****
Flood Tolerant paddy seed	0.041	0.004	0.076
Full cover Low pay-out	0.063	0.091	0.014
Full cover High pay-out	0.334***	0.404****	0.041
Limited cover High pay-out	0.269***	0.290***	0.516***
Post flood seed	0.272***	0.305****	0.896****
Central government insurance provider	0.233***	0.253***	0.031
State government insurance provider	0.121	0.059	-0.651***
Local co-operative government insurance provider	0.157*	0.165	0.110
MFI insurance provider	0.014	-0.031	0.949****
Number of households	307	307	
Number of choice-sets per household	10	10	
Total number of observations (N)	9210	9210	
Log Likelihood	-2937.43	-2784.02	
AIC	5896.86	5610.041	
BIC	5963.18	5759.73	

To interpret the results in terms of farmers' willingness to pay for insurance and stress tolerant varieties, we calculate the WTP for different attribute levels. In Table 5, the first row gives the average WTP for the non-status quo ASC, which implies that farmers are willing to pay Rs. 109 per Katha for a bundled insurance with paddy seed (regular variety not the flood tolerant variety) and Rs. 600 pay-out after 12 days of continuous submergence (i.e., Limited cover Low pay-out), when offered by a private insurance company. The 95% confidence interval (CI) for the WTP for non-status-quo ASC is from Rs.85.1 to Rs. 140.2.

Interestingly the average marginal willingness to pay for a flood-tolerant (FT) seed variety is only Rs 0.3 and the 95% confidence interval is between Rs. -7.3 to Rs. 7.5. So, for several respondents the willingness to pay is negative and for the respondents with positive WTP for flood tolerant variety is only Rs7.5[4]. This is likely due to the yield penalty of flood tolerant seeds under normal conditions. The dislike for yield penalty under normal conditions have been demonstrated in other studies also – for example. Ward (Ward, Ortega, Spielman, Kumar, & Minocha, Demand for complementary financial and technological tools for managing drought risk, 2020) found negative WTP for drought tolerant seeds amongst farmers in Bangladesh.

Table 5 - Marginal willingness to pay estimates from RPL model

Parameters	Lower Limit 2.5%	Mean	Upper Limit 2.5%
Alternative specific constant – non - status quo	85.1	109.2	140.2
Flood Tolerant paddy seed	-7.3	0.3	7.5
Full cover Low pay-out	-5.4	6.1	17.1
Full cover High pay-out	14.3	26.8	40.0
Limited cover High pay-out	7.0	19.3	31.8
Post flood seed	11.3	20.3	30.1
Central government insurance provider	5.1	16.8	29.1
State government insurance provider	-9.9	3.9	18.4
Local co-operative government insurance provider	-2.1	11.0	24.7
MFI insurance provider	-18.0	-2.0	13.9

In terms of the insurance component, farmers on average are willing to pay an additional Rs. 21.45 for "Limited cover High pay-out" (i.e., Rs. 950 pay-out after 15 days of continuous submergence) insurance instead of the base category of Rs. 600 pay-out after 12 days of continuous submergence.

And "Full cover High pay-out" option (i.e., Rs. 950 pay-out after 12 days of continuous submergence) the average WTP over the base category is an additional Rs. 26.63. So irrespective of the trigger day, farmers are willing to pay more for the high pay-out (and it is slightly higher if the trigger for high pay-out is after 12 days as compared to 15 days). Interestingly we could not find any significant positive WTP for "Full cover Low pay-out" (i.e., Rs. 600 pay-out after 7 days of continuous submergence) insurance. This implies that farmers are not willing to pay more for getting the 600 Rs pay-out after 7 days instead of 12 days. So, our results indicate that farmers are less willing to pay additional to reduce their trigger day for insurance pay-out, as compared to the actual pay-out that is offered.

[4] assuming 5 Kg seeds are required on average per acre, this amounts to ~Rs 33 additional amount per kg for the product.

The average WTP for post flood seeds is Rs. 21.74 per Katha. Some of the farmers may find it difficult to use the seed before Rabi season as the field is often not ready according to them, but the pay-out of high-value vegetable crop seeds in kind to flood affected farmers has significant positive marginal utility. After the flood, vegetable seeds are often not available promptly and farmers may not have the fund to at that time to buy the seeds. However, getting the seeds as a form of in-kind insurance pay-out will enable them to cultivate high – value vegetables and earn more income, after the flood has receded and field is ready for cultivation.

There is also significant preference for role of government in insurance provision. Farmers are willing to pay Rs. 18.6 more if Central Government is the insurance provider as compared to private insurance providers. This is much higher compared to other type of insurance providers like State Government, local co-operatives, or Micro-finance institutions, which show weak or no significant marginal preference compared to private insurance providers. This is important given the trust issue with other type of insurance providers, Central Government's involvement is of primary importance in the agricultural insurance sector.

c. Individual level coefficients

From the coefficient estimates of the RPL, we can also estimate the individual level coefficients for the respondents in our sample and then correlate with different characteristics of the farmers. In particular, we check if are systematic differences between preferences for "bundled insurance" products across our 3 groups of farmers. Also, we estimate if farmer heterogeneity in preference is correlated with location of the village in terms of flood prone zones.

Table 6, which compares the individual level coefficients across these 3 groups show that only for two coefficients, there is significant difference. The coefficient for alternative specific constant is lowest for non-project farmer, slightly higher for "Index insurance" farmers and highest for "Bundled Insurance" farmers. It implies that "Bundled Insurance" farmers have significantly higher preference for the insurance product over the opt-out option, as compared to control farmers. Similarly, "Bundled Insurance" farmers have also higher preference for post flood seed coefficient more than "Index insurance" project and control farmers. One explanation could be that project farmers with prior experience of an index insurance product are willing to pay more for an insurance product as compared to control farmers. However, we should be careful of such an interpretation, since Table 1 and Table 2 show that "Bundled Insurance" villages are in more flood-hazard zones and the "Bundled Insurance" farmers are more highly educated, mostly from general category caste and cultivating larger areas. So, these could be other reasons why the preference for insurance product was higher for "Bundled Insurance" farmers. Interestingly even for "Bundled Insurance" project farmers the preference for flood-tolerant paddy variety was low. Next, we also compare individual preferences across villages in different flood hazard zones.

Table 6 – Individual level coefficients across different groups of farmers

	Bundled insurance farmers	Index insurance farmers	Control	Total	Significance
Alternative specific constant – non - status quo	1.91	1.63	1.39	1.64	***
Flood Tolerant paddy seed	0.01	0.00	0.00	0.00	n.s.
Full cover Low pay-out	0.09	0.09	0.09	0.09	n.s.
Full cover High pay-out	0.40	0.40	0.40	0.40	n.s.
Limited cover High pay-out	0.27	0.28	0.31	0.29	n.s.
Post flood seed	0.39	0.20	0.34	0.31	*
Central government insurance provider	0.25	0.25	0.25	0.25	n.s.
State government insurance provider	0.06	0.03	0.09	0.06	n.s.
Local co-operative government insurance provider	0.17	0.16	0.17	0.17	n.s.
MFI insurance provider	-0.02	-0.05	-0.02	-0.03	n.s.

This is also evident from Table 7, which shows that farmers in High Flood Hazard Zones have significantly higher preference for insurance product as compared to the opt-out option. This can probably be expected since farmers from flood hazard zones likely to be more interested in insurance products.

Table 7 – Individual level coefficients across different flood hazard zones

	High Flood Hazard Zone	Medium Flood Hazard Zone	Low Flood Hazard Zone	Total	Significance
Alternative specific constant – non - status quo	1.85	1.63	1.40	1.64	****
Flood Tolerant paddy seed	0.01	0.00	0.00	0.00	n.s.
Full cover Low pay-out	0.09	0.09	0.09	0.09	n.s.
Full cover High pay-out	0.40	0.40	0.40	0.40	n.s.
Limited cover High pay-out	0.29	0.33	0.26	0.29	n.s.
Post flood seed	0.34	0.31	0.26	0.31	n.s.
Central government insurance provider	0.25	0.25	0.25	0.25	**
State government insurance provider	0.05	0.10	0.04	0.06	n.s.
Local co-operative government insurance provider	0.17	0.17	0.16	0.17	***
MFI insurance provider	0.00	0.03	-0.10	-0.03	n.s.

7. Conclusions

With climate change, the frequency of agricultural shocks like flood, drought etc. are expected to increase and thus increasing the risk of agricultural activities. There is thus need for adoption of risk management technologies and practices. Both stress tolerant seeds and crop insurance are important instruments of risk management. Providing seeds for a short duration post-flood crop after flood water has receded is another method that can contribute to managing the losses from a flood event. Bundling these different instruments into one product for managing risks can crowd-in more investments from farmers into these risk management products. Using a discreet choice experiment with farmers in the flood affected zones of Bihar, we estimated the willingness to pay for these different risk management instruments. We found that farmers have a very high preference for a flood index insurance product, but the preference for stress-tolerant seeds are not very high on average with negative preference for many farmers. This is likely to the fact that stress tolerant varieties have a yield penalty under normal conditions when compared to some of the prevalent high-yielding varieties. More awareness and financial incentives at the initial stages might be required for farmers to adopt stress tolerant seeds that have yield penalty under normal conditions. Among the respondents there is also clear preference for availing post-flood seeds for cultivation and the central government as the insurance provider. This trust with government as the provider as compared to private insurance companies has important implications for the roll-out of any such product. Finally, in our results we find correlation between higher preference for insurance and whether villages are in high-flood prone zones. Given the novelty of these different instrument like insurance and stress tolerant seeds etc, it is important to understand preferences for them amongst farmers and overall, our results suggest that bundled insurance products if properly targeted have the potential to be adopted by flood affected farmers.

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ANNEXURE 1 – Rationale for choosing the attribute levels

Yield estimates

Using data from Odisha and eastern UP, Yamano T. (2013) found that for Swarna-Sub-1 under normal conditions yield is about 4.5 tonnes/ hectare and under flood conditions yield for Swarna Sub-1 is as follows - for 1-7 day submergence = 3.7 tonnes/ha; 8-14 day submergence=2.9 tonnes/ha; >15 day submergence=1 tonnes/ha. Yamano T. (2013) also found that Swarna-Sub 1 (submergence tolerant) has significant yield advantage over Swarna (non-submergence tolerant) under different submergence conditions estimated as an advantage of 0.7 tonnes/ha for submergence for 1-7 day duration and 1.5 tonnes/ha for submergence for 8-14 days. For submergence longer than 14 days, the yield difference becomes insignificantly small. Ismail et al (2013) found similar yield advantages in their paper. Under normal conditions their yields are similar without any significant difference. But there is another Hybrid variety which is very common in this region called Arize 6444, that have higher yield around 5.4 tonnes/hectare under normal conditions but suffers badly under flood conditions. We are not aware of any literature that estimates yield of Arize-6444 under various flood conditions. Given our hypothetical nature of the exercise we take yield of **Arize-6444 under flood conditions** same as that of Swarna. So, for our discreet choice example, Swarna-Sub 1 has yield advantage over Arize 6444 under flood conditions that becomes zero under extreme flood, but in normal conditions Arize 6444 has a yield advantage over Swarna-Sub 1.

Insurance attribute levels

Since we are assuming that for Arize-6444 variety, flood for up to 14 days meant loss of 72 kgs/Katha ~ 972 Rs/ Katha (@13.5 Rs per kg), while for 7 days flooding meant loss of 45 kgs/Katha i.e., 608 Rs/Katha. For ease of comprehension, we will take the high pay out as 950 per Katha, while low pay out as 600 per Katha. Trigger day up to 7 days for insurance is taken as moderate floods, while 15 days of continuous submergence is taken as extreme flood. We take the middle point of 8-14 days flooding i.e., 12 days as another trigger day when the yield gap is assumed to be highest. Given 3 trigger days (7 days, 12 days, and 15 days) and 2 pay-out levels, we can have 6 combinations. But we don't include the "lowest trigger day with highest pay-out" and "highest trigger day with lowest pay-out" in our design, as they would not be offered in the real world.

Price attribute levels

In our discreet choice experiment we design the bundled product for managing risk in 1 Katha of land. In the Index based Insurance pilot, the premium varied from 6% -13% based on flood risk of each village and the sum insured was ~20000 Rs. / hectare i.e., 368 Rs. /Katha. So premium was between 22-47 Rs/Katha. So average premium can be taken as 35 Rs/Katha i.e., 9.5% of sum insured. Accordingly, for 950 Rs. insured sum, premium would be around 90 Rs. If the insurance is bundled with 0.23 kg of seed per Katha (assuming 5 Kg required on average per acre), the per Katha cost (@35rs/kg), comes to ~8 Rs. /Katha. So, for full insurance + seed for 1 Katha ~=98 Rs. With additional administrative cost + normal profit, we take 110 as the highest price. The cheapest option for farmer would be to use local variety without any insurance and post flood activity. For that case, price is assumed to be just 10 Rs.[5] per Katha.

[5] For local variety approximately 15-20 kg seed per acre is required. "bhasar" is one variety which is common. Local varieties are normally not purchased from market. But imputed cost for it will be between 10-15 Rs. So, for 1 Katha imputed cost for desi variety will come to 12.5*(17.5/22) ~= 10 Rs. /Katha.

ANNEXURE 2 – Example Choice Card

BLOCK 1		CHOICE SET 2 OF 11		
		ALTERNATIVE A	ALTERNATIVE B	NEITHER
Seed Type with different yield is provided for 1 katha of land	Yield under normal conditions	100 Kg/Katha	83 Kg/Katha	I choose neither Alternative A or Alternative B.
	Yield up to 1-7 days flood submergence	55 Kg/Katha	68 Kg/Katha	
	Yield under 8-15 days flood submergence	28 Kg/Katha	53 Kg/Katha	
	Yield under more than 15 days flood submergence	6 Kg/Katha	6 Kg/Katha	
INSURANCE PAYOUT per katha of land		RRs. 950 paid out if 12 days flood submergence	RRs. 950 paid out if 15 days flood submergence	
Provider of insurance		State Government	Local Co-operative	
Provided with seed for short duration vegetable of farmer's choice, for post-flood CULTIVATION before Rabi cultivation				
PRICE per katha		70 RS	10 RS	