The Role of Land Market in Achieving the Scale for Adaptation to Climate Change: Evidence from Bangladesh

Mohammad Islamul Haque

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Abstract

This paper studies whether climate-induced shifts in land productivity can trigger structural adaptation in agriculture by overcoming long-standing frictions in land markets. I focus on coastal Bangladesh, where rising sea levels have increased dry-season soil salinity beyond the threshold at which conventional crops can survive. Using high-resolution census data on over one million farm households, I exploit a natural discontinuity in salinity at the hydrological boundary between the tidally active and mature regions of the Bengal delta. I implement a fuzzy spatial regression discontinuity design and an instrumental variables strategy to estimate the causal effect of high salinity on land use and farm structure.

I find that salinity above 12 dS/m leads to a large reallocation of land from crop farming to aquaculture—by 32 to 50 decimals per household—and induces a 52 percent increase in average farm size and a 23 percent rise in farm size inequality. This transition is not driven by land sales, which remain stagnant, but by consolidation through the rental market: the share of households renting in land declines, while land rented per renter doubles. I show that this process is shaped by local frictions. In particular, land reallocation is significantly more responsive in villages with greater religious diversity (which improves cross-group contract enforceability) and less responsive in villages with high land parcel fragmentation (which raises transaction costs). These findings highlight the potential for market-mediated adaptation to climate change even in historically stagnant land markets, but also underscore the role of social and spatial frictions in shaping who adapts and how.

1 Introduction

Reallocation of farmland in response to evolving comparative advantage has the potential to substantially mitigate the adverse effects of climate change on farm incomes (Costinot, Donaldson, and Smith, 2016). However, when the new production technique exhibits higher economies of scale relative to the existing one — as is often the case when switching from traditional crop farming to more resilient commercial farming — the transition requires the consolidation of multiple contiguous land parcels. This is particularly challenging in developing countries, where land ownership is highly fragmented.[1]

Frictions in land market transactions — such as weak property rights, cultural resistance to land sales, and poor contract enforcement — can further hinder the consolidation process. Even in the absence of such frictions, consolidation requires multiple land market transactions, which can expose participants to hold-up problems that eliminate the surplus necessary to incentivize aggregation. These barriers have contributed to historically low rates of technology adoption and persistently high productivity dispersion in the agricultural sectors of developing countries (Foster and Rosenzweig, 2022). Climate change may exacerbate this dispersion if these consolidation barriers prevent land reallocation in accordance with shifting comparative advantage (Mendelsohn, 2008).

This paper exploits exogenous variation in soil salinity arising from a hydro-geological boundary and employs both a fuzzy Regression Discontinuity Design (RDD) and an instrumental variables (IV) approach to examine whether the land market can facilitate the consolidation required for adaptation to salinity intrusion in the farmlands of coastal Bangladesh. Specifically, the paper addresses three questions: (i) To what extent can farmers adapt to rising soil salinity through reallocation of farmland? (ii) What mechanisms enable the land consolidation necessary for this reallocation? and (iii) What frictions constrain the land reallocation process?

Coastal Bangladesh is often described as ground zero for the impacts of global warming–induced sea level rise. Relative high water levels in the region have been increasing at an average rate of 15.9 mm per year and up to a maximum of 17.2 mm per year (Pethick and Orford, 2013). Between 1973 and 2009, the area of farmland with dry-season soil salinity above 12 dS/m increased by as much as tenfold in some coastal districts (SRDI, 2010).[2] No

[1] For example, while fewer than 10 percent of farms in the United States are smaller than 10 acres, more than 80 percent of farms in India, China, Bangladesh, and Indonesia fall below this threshold.

[2] dS/m (decisiemens per meter) is a unit of electrical conductivity commonly used to measure salinity in water and soil.

known crop variety can tolerate salinity levels this high. Without adaptation, the livelihoods of millions of farmers in these regions would be at severe risk.

In response, many farmers have adapted by transitioning to brackish-water aquaculture, primarily involving shrimp and crab farming—species that are resilient to high salinity. This land-use shift involves constructing earthen embankments around former crop fields to trap saline tidal water, creating a controlled environment suitable for cultivating salt-tolerant aquatic species.[3]

However, this adaptation process requires overcoming a major barrier: aquaculture exhibits significantly higher economies of scale than traditional agriculture, and landholdings in the region are highly fragmented. As shown in figure 12 and figure 13, rice farming can be profitably undertaken even on very small plots, whereas aquaculture has a minimum efficient scale of 35 decimals. Beyond this threshold, aquaculture displays substantially steeper returns to scale than crop farming.

Furthermore, figure 15 shows that more than 60 percent of agricultural plots in developing countries are smaller than 15 decimals. This implies that reallocating land from crops to aquaculture typically requires consolidating multiple contiguous plots, which in turn demands several land market transactions. Frictions in these markets—such as weak contract enforcement or coordination failures—can hinder or delay this reallocation process. Historically, such barriers to consolidation have contributed to low mechanization and persistently poor productivity in Bangladesh's agricultural sector (figure 11).

At the same time, salinity intrusion increases the opportunity cost of failing to reallocate land to aquaculture. This raises a key empirical question: to what extent can the land market facilitate the consolidation needed to achieve the scale required for transitioning from crop farming to aquaculture?

I provide causal evidence on this question by exploiting the plausibly exogenous frontier between the tidally active delta and the mature delta in coastal Bangladesh. Salinity levels in this region are determined by the interaction between the incoming flow of tidal saline water from the Bay of Bengal and the outgoing flow of freshwater through rivers and channels. The boundary between the tidally active and mature delta is shaped by how far tidal influence extends inland through this river network. As a result, the frontier creates a natural and sharp discontinuity in salinity exposure that I use as an instrument to estimate the causal effects of salinity, employing both a fuzzy spatial regression discontinuity (RD) design and

[3]This method of adaptation is widely practiced in other coastal regions across South Asia, Southeast Asia, China, and various other countries facing salinity intrusion.

an instrumental variables (IV) approach.

Figure 8 shows a sharp increase in the probability of being in a high-salinity zone within the tidally active delta; nearly all villages in this region experience dry-season salinity levels above 12 dS/m. Figure 9 further illustrates that this discontinuity occurs precisely at the frontier and fades away as we move in either direction away from the boundary. Table 3 confirms this pattern quantitatively: the probability of salinity exceeding 12 dS/m increases by approximately 43 to 60 percentage points inside the tidally active delta, depending on the specification.

Figure 8 shows a sharp increase in the probability of being in a high-salinity zone within the tidally active delta. In fact, almost all villages in this region exhibit salinity levels above 12 dS/m. Furthermore, figure 9 illustrates that this discontinuity occurs precisely at the frontier and disappears as we move further in either direction from the boundary.

Table 3 confirms the visual evidence. Columns 1 and 2 present the first-stage estimates from the fuzzy RD and 2SLS approaches, respectively. The probability of having salinity above 12 dS/m increases by approximately 43 to 60 percentage points inside the tidally active delta, depending on the specification. Importantly, the first-stage F-statistics—17 for the RD and 228 for the 2SLS—are sufficiently large to rule out concerns about weak instruments.

Table 4 presents the second-stage estimates of the effect of high salinity (above 12 dS/m) on the amount of land allocated to aquaculture. Across all specifications, we find a statistically significant and sizable positive effect of salinity on aquaculture land allocation. Specifically, high salinity leads to an increase of 32 to 50 decimals in aquaculture land, depending on the model. This implies a 2.5 times increase in the amount of land allocated to aquaculture in affected areas. These findings are consistent with agronomic science that no crop or rice variety is resilient above 12 dS/m. A key threat to the exclusion restriction is that variation in land use could reflect permanent differences in soil quality other than salinity. Table 7 addresses this concern by showing that land allocated to rice farming in the wet season—when salinity is low—remains unchanged. The increase in aquaculture land in the dry season corresponds to a decline in dry-season rice cultivation. Further robustness is provided in table 8, which shows that the decline in dry-season rice cultivation is much larger for salinity-sensitive high-yielding varieties than for relatively tolerant local varieties. This suggests that the changes are driven by salinity, not by other unobserved seasonal confounders. Taken together, these results provide strong evidence that farmers in high-salinity areas are reallocating land from traditional crops to aquaculture as a form of climate

adaptation.

Next I test the hypothesis that switching from crop farming to aquaculture requires substantial consolidation due to minimum efficient scale and higher economies of scale in aquaculture. Column 1 of table 9 shows that salinity levels above 12 dS/m lead to a statistically significant increase in average farm size—by about 52 percent relative to the control mean. Column 3 shows a corresponding increase in the Gini coefficient of farm size, which rises by approximately 23 percent. These results strongly suggest that reallocation from crops to aquaculture involves significant consolidation of farmland. One potential concern is that these differences may be due to pre-existing variation in landholding patterns across the tidally active and mature deltas. However, columns 2 and 4 of table 9 show that even after controlling for total land ownership and the Gini coefficient of owned land, the effects of high salinity on farm size and its consolidation remain significant. This suggests that the observed changes are not merely due to historical differences in land ownership structures. Nonetheless, these results do not yet identify whether consolidation occurs through the land purchase market or the rental market.

Therefore, I investigate the mechanism more directly by examining changes in land transactions. Historically, the land sales market in developing countries has been largely inactive due to cultural norms that discourage selling inherited land (Foster and Rosenzweig, 2022). Consistent with this, table 10 shows that salinity intrusion has no significant effect on either total land ownership or the Gini coefficient of land ownership at the village level. This implies that most consolidation likely occurs via the rental market.

The rental market can facilitate both allocative efficiency and consolidation. If rental market consolidation is occurring, we would expect to see (i) fewer households renting in land and (ii) a higher amount of land rented conditional on positive renting. Table 11 supports this: columns 1 and 2 show a 62 percent decline in the share of households that rent in land in high-salinity areas, while columns 5 and 6 show a 100 percent increase in the amount of land rented per renter. A threat to identification is the possibility of pre-existing differences in rental market activity across regions. Table 12 rules this out by showing no difference in housing rental activity between the tidally active and mature delta areas. Together, these results provide strong evidence that rental market consolidation plays a crucial role in enabling farmers to reach the scale required for adaptation to salinity intrusion. Nonetheless, there could still be frictions and barriers that limit the extent of land consolidation.

An important friction impeding land consolidation in response to climate-induced salinity intrusion stems from challenges in enforcing land rental contracts across religious groups. In coastal Bangladesh, where both Muslim and Hindu communities have historically coexisted, land fragmentation implies that rental contracts often need to be executed between members of different religious communities. Local political leaders, who often play an informal role in mediating land disputes and contract enforcement, may face conflicting incentives. On one hand, they have electoral motives to remain impartial in religiously diverse settings to secure votes from both Muslims and Hindus. On the other hand, in less diverse areas, politicians might be able to win offices by polarization. Hence, when votes from both the groups aren't required to win elections, there may be fewer political costs associated with favoring one group over another, which can undermine contract enforcement for inter-religious rentals.

Empirical evidence supports the importance of religious diversity in mitigating these enforcement frictions. To address endogeneity concerns (e.g., that recent aquaculture expansion may have caused migration and changed religious composition), the study instruments current diversity with its historical level from the 1961 census. The results in table 14 show that religious diversity significantly amplifies the extent land reallocation to aquaculture in response to saltwater intrusion. Specifically, villages above the median level of historical religious diversity saw an additional 28.8 decimals of aquaculture land per household in high-salinity zones, representing a 100% incerase over and above the average treatment effect.

However, one might be concerned that religious diversity might affect aquaculture productivity through other direct effects such as improved public goods provision. But, results in table 15 reveal that historical religious diversity does not predict access to public or private goods such as concrete housing, sanitary toilets, or electricity, supporting the validity of the exclusion restriction. Furthermore,table 16 provides strong evidence all across the board that more religious diversity results in higher rental market activities. Together, these findings indicate that weak contract enforcement between religious groups is a substantial barrier to climate adaptation through land market consolidation.

A major barrier to adaptation via land reallocation is the high degree of land parcel fragmentation prevalent in many parts of rural Bangladesh. When landholdings are divided into numerous small and spatially scattered plots, consolidating enough land to meet the scale requirements for aquaculture becomes substantially more difficult. Table 17 provides empirical evidence that land fragmentation significantly dampens the adaptive response to salinity. While households in high-salinity areas (> 12 dS/m) increase aquaculture land by an average of 40.46 decimals, this response is attenuated by 22.48 decimals in villages where

land fragmentation is above the median. This negative interaction effect is statistically significant, indicating that higher fragmentation imposes substantial consolidation frictions even in the presence of strong climatic incentives to adapt.

This paper contributes to two broad strands of literature in development economics and the economics of climate change adaptation. First, while existing work has documented the historical stagnation in land consolidation and the resulting productivity dispersion in the agricultural sector of developing countries, there is limited empirical evidence on the frictions that impede consolidation (Foster and Rosenzweig, 2022, 2011). I provide novel evidence that rental contract enforcement frictions across religious groups can constrain land consolidation, particularly in settings where rental transactions are required to assemble viable farm sizes. The literature to date has primarily examined consolidation in the context of transitioning from smallholder to large-scale farming to facilitate mechanization and improve productivity. I show that this classic constraint re-emerges under climate change as evolving comparative advantage makes aquaculture more viable than crop farming in salinity prone coastal areas. My results demonstrate that the land rental market can enable this transition—even when it requires attaining a minimum operational scale—by circumventing long-standing barriers to consolidation.

Second, this paper contributes to the literature on agricultural adaptation to climate change. In particular, it addresses a largely overlooked dimension: land use adaptation in response to salinity intrusion and the role of the rental market in enabling scale-dependent transitions. The existing literature has generally found limited evidence of adaptive responses in agriculture to gradual changes in temperature, precipitation, or groundwater availability (Burke and Emerick, 2016; Blakeslee et al., 2020; Hornbeck and Keskin, 2014). I provide the first direct evidence of land reallocation from crop farming to aquaculture as a response to rising soil salinity. Moreover, I show that this transition occurs primarily through the rental market, which facilitates the consolidation needed for aquaculture adoption in a highly fragmented landholding environment.

The remainder of the paper is organized as follows. Section 2 provides background on sea level rise and salinity intrusion in coastal Bangladesh, the agronomic consequences for crop production, and the emergence of aquaculture as a potential adaptation strategy. Section 3 describes the salinity and agricultural census data used in the analysis and provides descriptive evidence on land use patterns and salinity exposure. Section 4 outlines the empirical strategy, including a fuzzy spatial regression discontinuity design and an instrumental variables approach. Section 5 presents the main results on land reallocation, farm size con-

solidation, and the role of the rental market, and explores heterogeneity by religious diversity and land fragmentation. Section ?? concludes by discussing implications for land market policy and climate adaptation planning.

2 Background and Motivations

2.1 Sea Level Rise and Salinity Intrusion in Bangladesh

Bangladesh is one of the most vulnerable countries to the threats posed by sea level rise. The southwestern coastal region lies within the Ganges-Brahmaputra-Meghna (GBM) delta and has an elevation of only one to three meters above sea level (Lázár et al., 2020). Moreover, high water levels in this region have been rising at an average rate of 15.9 millimeters (mm) per year, reaching a maximum of 17.2 mm per year over the past three decades (Pethick and Orford, 2013). The combination of low elevation and gradually increasing water levels has led to a substantial rise in soil salinity in the coastal districts.

Figure 1 compares the extent of farmland with soil salinity above 8 dS/m—a level known to be extremely harmful for traditional crops—in 1973 and 2009, for three southwestern coastal districts of Bangladesh. Between 1973 and 2009, the amount of farmland with salinity exceeding 8 dS/m increased by a factor of two to twelve across these districts.

Furthermore, Figure 2 illustrates a clear seasonal pattern in salinity levels. Salinity begins to rise during the dry season in February and peaks around April or May. It then declines with the onset of the monsoon in June and remains relatively low through the end of January. As a result, the increase in salinity primarily affects dry-season crop farming, traditionally known as Rabi farming.

2.2 Agricultural Science of Salinity Tolerance

Bangladesh is a predominantly rice-consuming country, and traditionally, more than 95% of its farmland has been used for rice cultivation. However, rice farming is highly sensitive to soil salinity. For example, traditional high-yielding varieties (HYVs) of rice can tolerate only up to 3 dS/m of salinity, and their productivity declines by nearly 40% at 8 dS/m (Tanji and Kielen, 2002). Even the most widely used salt-tolerant variety, BRRI Dhan-47—developed by the Bangladesh Rice Research Institute (BRRI)—can tolerate salinity up to 8 dS/m without yield loss, but its productivity drops by around 43% at 12 dS/m (Radanielson et al., 2018). Some newer varieties, such as BRRI Dhan-99 and BINA Dhan-10, are claimed to be resilient up to 12 dS/m.

Wheat, the most salt-tolerant alternative Rabi crop, can only withstand salinity levels up to 6 dS/m, and its yield declines by 14.2% at 8 dS/m (Tanji and Kielen, 2002). Therefore, when salinity exceeds 12 dS/m, traditional crop farming becomes virtually unviable. This poses a major threat to the livelihoods of millions of farmers in Bangladesh's coastal regions. Not surprisingly, multiple risk assessments by U.S. intelligence agencies have warned that even modest increases in salinity due to sea level rise could lead to widespread livelihood loss, large-scale migration, and social conflict in the absence of adaptation (NIC, 2017; NSMIP, 2020).

2.3 Adaptation to Salinity via Land Reallocation to Aquaculture

In response to rising soil salinity, many farmers in the worst-affected southwestern coastal areas of Bangladesh have begun reallocating their land from traditional crop farming to salinity-resistant aquaculture during the dry season. This adaptation involves constructing earthen embankments around plots to trap tidal brackish water and cultivate shrimp, crabs, swamp eels, and other species that thrive in saline environments. The specific aquaculture practices vary by location, depending on the salinity levels of nearby surface water sources.

In coastal areas with persistently high salinity, once tidal water is allowed into the fields, crop farming becomes unfeasible even during the monsoon. These lands are thus used for aquaculture year-round. Further inland, monsoonal rainfall helps leach salt from the soil, making rainfed rice farming feasible during the wet season. Since shrimp and crab farming are unproductive when salinity is too low, many farmers drain their fields and plant rainfed rice during the monsoon, when salinity naturally declines due to heavy rainfall.[4]

Widespread adoption of this adaptation strategy accelerated in the 1980s, following trade and exchange rate liberalization that opened up export markets in Europe, North America, and Japan. However, this raises an important question: is the shift to aquaculture driven primarily by environmental necessity or by profitability? It is possible that farmers are intentionally allowing saline water into otherwise cultivable crop fields to take advantage of more profitable aquaculture. In this case, salinity intrusion would be an outcome—not a cause—of land use change. Distinguishing between these possibilities requires rigorous causal analysis of the effect of salinity on farming choices.

2.4 Difference in Economies of Scale and Need for Consolidation

Adoption of aquaculture as an adaptation strategy is particularly surprising given the significant difference in economies of scale between aquaculture and traditional rice farming.

[4]Shrimp and crab cultivation typically require salinity levels of at least 15 dS/m.

Aquaculture exhibits much higher scale economies than rice farming, making it less viable on small landholdings. Figures 12 and 13 show the relationship between plot size and profit per decimal of land for rice farming and aquaculture, respectively.

Figure 14, which superimposes both relationships, reveals two key facts: (i) rice farming can be profitable even on very small plots, while aquaculture requires a minimum of approximately 35 decimals to generate positive economic profit; and (ii) beyond this threshold, aquaculture displays much steeper returns to scale than rice.

Given this difference, transitioning from rice to aquaculture typically requires land consolidation. However, Figure 15 shows that the median agricultural plot size in Bangladesh is only around 15 decimals. This implies that, in most cases, adaptation to rising salinity via aquaculture necessitates combining multiple contiguous plots—posing a significant logistical and institutional challenge in a highly fragmented land market.

2.5 Role of Land Market and Frictions in Land Consolidation

In a functioning land market, farmers with the capital and skills to undertake aquaculture could rent or purchase contiguous plots from others to consolidate land and engage in profitable aquaculture operations. However, given the historical stagnancy in land consolidation in many developing countries, including Bangladesh, it is unclear whether the land market can facilitate the scale required for adaptation.

For instance, agriculture in Bangladesh is still dominated by labor-intensive techniques, which operate at low scale and yield low productivity. In figure 11, the relationship between profit per acre and scale of operation in rice farming is superimposed on the distribution of plot sizes. It is clear that most plots are very small and operate at low productivity levels. This pattern suggests there are significant potential gains from consolidation that remain unrealized.

The persistence of fragmented landholdings indicates that there are substantial frictions in the land market. For example, cultural norms discourage the sale of land inherited across generations. In addition, weak property rights may discourage landowners from renting out their land due to fears of losing ownership. Where contracts are not enforceable, renters may also be reluctant to make fixed investments. Even in the absence of such frictions, hold-up problems in multi-party negotiations could extract the surplus that would otherwise incentivize consolidation.

Thus, the extent of misallocation implied by figure 11 can only be rationalized if the total costs from all these frictions outweigh the productivity gains from consolidation. In such a setting, smallholder farmers may entirely fail to adapt to climate change through

aquaculture unless these barriers can be overcome.

On the other hand, if climate change raises the cost of misallocation enough to tip the balance, then it may become feasible to achieve the required scale through land market transactions, even in the presence of historical frictions. This paper provides the first causal evidence on whether, and to what extent, the land market plays a role in overcoming these frictions to enable climate change adaptation.

2.6 Tidally Active Delta and Natural Variation in Soil Salinity

Bangladesh lies on a deltaic plain formed by the deposition of alluvium from rivers originating in the Himalayas and the eastern hills of India. This deltaic plain is commonly divided into four zones: active delta, tidally active delta, mature delta, and moribund delta. Figure 5 illustrates this classification based on existing literature (Islam and Gnauck, 2008; Passalacqua et al., 2013).

For the purposes of causal identification, this study exploits the contrast between the tidally active delta and the mature delta. There are two important differences between these regions. First, the tidally active delta contains the bulk of the tidal river network, through which semi-diurnal tides flow inland from the Bay of Bengal. As a result, tidal influence is much stronger in this region. Second, there is a sharp drop in elevation at the boundary between the mature and tidally active deltas. As shown in figure 6, a 1-meter elevation contour line runs almost precisely along this frontier.

Due to the lower elevation and stronger tidal exposure, villages within the tidally active delta are more susceptible to salinity intrusion, both through capillary rise and occasional tidal overflow. I argue—and later demonstrate—that these two features lead to a discontinuous increase in soil salinity as one crosses from the mature delta into the tidally active delta.

This pattern is also supported by visual evidence: figure 7 shows that the area with the highest salinity levels aligns closely with the tidally active delta, and that salinity increases sharply at the border. I exploit this natural variation in salinity across the frontier to implement a fuzzy spatial regression discontinuity (RD) design. Additionally, I use the same boundary as an instrument for high salinity (i.e., levels above 8 dS/m) in an instrumental variables (IV) specification that complements the RD results.

3 Data and Descriptive Statistics

3.1 Salinity Data

I use soil salinity data from a survey conducted by the soil resources development institute (SRDI) in 2009 in the coastal regions of Bangladesh. A field survey was conducted in the south-western coastal arable lands excluding Sunderbans by multiple soil survey teams from SRDI in May, 2009. The sample points were chosen through traverse line methods. Selected traverse lines were changed or modified according to necessity during the field survey. The adjacent traverse lines were at an interval of 3-4 kilometers from each other. Along all the traverse lines 2500 soil samples were collected and analyzed in the laboratory to measure the salinity level. For more details on the survey and the testing methods please refer to SRDI (2010). On the basis of this survey information, coastal land areas were classified into five different categories: (i) 0 to 4 desi-Siemens per meter (dS/m), (ii) 4.1 to 8 dS/m, (iii) 8.1 to 12 dS/m, (iv) 12.1 to 16 dS/m, and (v) above 16 dS/m. Table 1 shows that out of more than 42 percent of the villages in my sample have a dry season soil salinity level above 12 dS/m, a level beyond which even the most resilient variety of rice suffer substantial productivity damage.

3.2 Agricultural Census Data

The primary analysis in this paper is based on agricultural census data of 2008. The agricultural census of Bangladesh 2008 was a full-count based household level census which collected data on household composition, land ownership, different types of land uses, agricultural assets, livestock etc. Data of all households of the country in both rural and urban areas were collected simultaneously. Entire country was divided into 1,53,945 Enumeration Areas (EAs). Each enumeration area had around 200 households in rural areas and around 300 households in urban areas and also a location map. The map was used to identify EAs correctly on ground. One enumerator was assigned the responsibility of one or two enumeration areas for data collection. Moreover, there were 19,529 supervisors, meaning one supervisor for 7 to 8 EAs. This was the most strictly monitored census in the history of Bangladesh. Moreover, after the completion of field work of full-count census, a post enumeration check was done in order to assess the census data quality. For further details on the agricultural census of 2008 please refer to BBS (2010).

Table 2 provides summary statistics of a set of variables for the region of our interest. The table shows that most of the land, asset, and livestock variables have distributions skewed to the right.

4 Empirical Strategy & Identification

As discussed before, one of the main challenges in identifying adaptation to soil salinity intrusion is the potential reverse causality issue. For example, since aquaculture is highly profitable, farmers might allow the saline water to flow into their lands and this can in turn increase the salinity level. Furthermore, other observed and unobserved meteorological, topological, and soil characteristics might affect both salinity level and productivity of aquaculture and crops. Finally, note that strategic sorting of farmers depending on the level of salinity is not a concern given that the focus of this paper is solely on efficient land use. In the presence of strategic sorting I will be capturing both the intensive and the extensive margins of the effects of salinity on land use, which is in fact the policy relevant parameter in this context.

4.1 Fuzzy Spatial Regression Discontinuity Approach

I exploit the plausibly exogenous border between the mature delta and the tidally active delta to employ a fuzzy spatial regression discontinuity (RD) design. As described in the background section, while very few areas within mature delta have more than 12 dS/m, almost all the areas within the tidally active delta have a salinity level above that threshold. Therefore, there is a sharp increase in the probability of having a soil salinity level above 12 dS/m as we move from the mature delta to the tidally active delta right at the border between them. I exploit this hydro-geological feature to employ a fuzzy RD design in order to identify the effect of salinity on land use choices. I use a standard local linear specification as follows:

$$Y_{hv} = \gamma\, N_v + \beta\, d_v + \phi\, d_v N_v + \lambda_l + \psi X_h + \epsilon_{hv} \tag{1}$$

In equation 1, Y_{hv} is the outcome of interest for household h in village v. Our main dependent variables are the amount of farmlands that are employed in different types of land use. Moreover, in the above equation, d_v represents the nearest distance from the centroid of village v to the frontier of tidally active delta in kilometers. I use positive distances for villages within tidally active delta and negative distances for villages in mature delta. In addition, X_h is a vector of farm covariates and λ_l represents longitude-quartile fixed effects. I use longitude-quartile fixed effects, following Ito and Zhang (2020), in order to avoid comparing villages that are located in distant longitudes. Finally, the treatment variable N_v is a dummy variable indicating whether the centroid of village v falls within the areas with a salinity level of more than 12 dS/m. Here, the parameter of interest is γ. I

use the 12 dS/m threshold for defining treatment because there is no variety of rice that is fully resilient beyond this level of salinity (Radanielson et al., 2018). As discussed earlier, the treatment variable N_v could be endogenous both due to reverse causality and omitted variable concerns. The identification strategy is to use the dummy Z_v indicating whether the centroid of village v falls within the tidally active delta as an instrument for the treatment variable to circumvent these problems. The exclusion restriction is that within a small neighborhood around the frontier between these two deltaic regions, being within tidally active delta only affects the land use choices through increased salinity level. Furthermore, I use local linear regression with triangular kernel weighting and Mean Square Error (MSE) optimal bandwidth to estimate the RD treatment effects (Calonico et al., 2014). Finally, since treatment varies at village level, I cluster the standard errors at village level, but the results are robust to clustering standard errors at a higher administrative level such as unions.

4.2 Instrumental Variable Approach

I also use a two stage least square approach (2SLS) using the same exogenous border between the mature delta and the tidally active delta as an instrument of whether a village falls within an area with above 8dS/m salinity to estimate the treatment effects. I use the following standard specification for the 2SLS approach:

$$Y_{hvd} = \gamma\, N_v + \mu_d + \psi X_h + \epsilon_{hvd} \tag{2}$$

In equation 2, Y_{hv} is the outcome of interest for household h in village v in district d. The outcome variables are as described earlier. Furthermore, μ_d represents fixed effect for district d and X_h represents a vector of household specific covariates. Finally, the treatment variable N_v is a dummy variable indicating whether the centroid of village v falls within the areas with a salinity level of more than 8 dS/m. Here, the parameter of interest is γ. As mentioned before, I use the 8 dS/m threshold for defining treatment because there is no variety of rice that is resilient beyond this level of salinity (Radanielson et al., 2018). Furthermore, as discussed earlier, the treatment variable N_v could be endogenous both due to reverse causality and omitted variable concerns. The identification strategy is to use the dummy Z_v indicating whether the centroid of village v falls within the tidally active delta as an instrument for the treatment variable to circumvent these problems. The exclusion restriction is that being within tidally active delta only affects the land use choices through increased salinity level.

The instrumental variable (IV) approach is used in addition to the fuzzy RD approach

to ensure that the results have more external validity. Moreover, as expected, fuzzy RD approach lacks sufficient power in most of the tests. Hence, IV approach works as a nice supplement in verifying the statistical significance of some results. However, the identification assumption is stronger for the 2SLS approach[5]. Nonetheless, I rule out a host of threats to the exclusion restrictions in my analysis.

4.3 Adaptation to Climate Change: Short Run vs. Long Run

There is a large literature that use two-way fixed effects (TWFE) models exploiting within location variation in weather variables over time to estimate adaptation to climate damage (Deschênes and Greenstone, 2007; Schlenker and Roberts, 2009; Dell et al., 2012). However, the weakness of this approach is that the economic agents would perceive the short term weather fluctuations as transitory and therefore not adjust their choices in the way they would have done in response to a long term change in climatic conditions. Hence, estimates from this approach are not inclusive of full range of adaptive behavioral responses to climate change. On the contrary, while cross sectional estimates are inclusive of adaptation to long term difference in climatic conditions, these are highly susceptible to omitted variable bias concerns (Mendelsohn, Nordhaus, and Shaw, 1994; Schlenker, Michael Hanemann, and Fisher, 2005). However, we can take advantage of the cross sectional variation in climatic conditions and get around the challenges from omitted variable bias concerns with either a spatial discontinuity (Hagerty, 2021) or a fine scale quasi-random variation (Blakeslee et al., 2020) in the climatic variable/marker of interest. The fuzzy RD and IV approaches described above helps us to do that in this chapter.

5 Results

5.1 First Stage

Figure 8 shows a sharp increase in the probability of being in a high-salinity zone within the tidally active delta. In fact, almost all villages in this region exhibit salinity levels above 12 dS/m. Furthermore, figure 9 illustrates that this discontinuity occurs precisely at the frontier and disappears as we move further in either direction from the boundary.

Table 3 confirms the visual evidence. Columns 1 and 2 present the first-stage estimates from the fuzzy RD and 2SLS approaches, respectively. The probability of having salinity above 12 dS/m increases by approximately 43 to 60 percentage points inside the tidally

[5]Essentially, the exclusion restriction has to be satisfied for a larger bandwidth in case of 2SLS than that of the fuzzy spatial RD approach

active delta, depending on the specification. Importantly, the first-stage F-statistics—17 for the RD and 228 for the 2SLS—are sufficiently large to rule out concerns about weak instruments.

5.2 Effects of Salinity on Land Use

Table 4 presents the second-stage estimates of the effect of high salinity (above 12 dS/m) on the amount of land allocated to aquaculture. Columns 1 and 2 report estimates from the fuzzy RD design, while columns 3 and 4 show results from the 2SLS specification. The fuzzy RD models include longitude-quartile fixed effects, while the 2SLS models include district fixed effects. Columns 2 and 4 additionally control for farm-level covariates.

Across all specifications, we find a statistically significant and sizable positive effect of salinity on aquaculture land allocation. Specifically, high salinity leads to an increase of 32 to 50 decimals in aquaculture land, depending on the model. Given that the average farm size in control areas is around 63 decimals, this implies a near-complete reallocation of land to aquaculture in affected areas. These findings are consistent with agronomic evidence discussed in subsection 2.2, which shows that no crop or rice variety is resilient above 12 dS/m.

A key threat to the exclusion restriction is that variation in land use could reflect permanent differences in soil quality other than salinity. Table 7 addresses this concern by showing that land allocated to rice farming in the wet season—when salinity is low—remains unchanged. The increase in aquaculture land in the dry season corresponds to a decline in dry-season rice cultivation.

Further robustness is provided in table 8, which shows that the decline in dry-season rice cultivation is much larger for salinity-sensitive high-yielding varieties than for relatively tolerant local varieties. This suggests that the changes are driven by salinity, not by other unobserved seasonal confounders.

Table 5 demonstrates that the reduced-form RD estimates remain robust across a wide range of bandwidths. Finally, table 6 shows that the RD estimates are not significant for placebo outcomes such as bamboo clumps and permanent trees, further strengthening the causal interpretation.

Taken together, these results provide strong evidence that farmers in high-salinity areas are reallocating land from traditional crops to aquaculture as a form of climate adaptation. This may explain why widespread salinity intrusion in coastal Bangladesh has not resulted in large-scale livelihood loss or conflict, contrary to some prior predictions.

5.3 Reallocation to Aquaculture via Farm Size Consolidation

This subsection provides empirical evidence for the hypothesis discussed in subsection 2.4, namely, that switching from crop farming to aquaculture requires substantial consolidation due to minimum efficient scale and higher economies of scale in aquaculture.

Column 1 of table 9 shows that salinity levels above 12 dS/m lead to a statistically significant increase in average farm size—by about 52 percent relative to the control mean. Column 3 shows a corresponding increase in the Gini coefficient of farm size, which rises by approximately 23 percent. These results strongly suggest that reallocation from crops to aquaculture involves significant consolidation of farmland.

One potential concern is that these differences may be due to pre-existing variation in landholding patterns across the tidally active and mature deltas. However, columns 2 and 4 of table 9 show that even after controlling for total land ownership and the Gini coefficient of owned land, the effects of high salinity on farm size and its consolidation remain significant. This suggests that the observed changes are not merely due to historical differences in land ownership structures.

Nonetheless, these results do not yet identify whether consolidation occurs through the land purchase market or the rental market. The next subsection investigates the mechanism more directly by examining changes in land transactions.

5.4 Farm Size Consolidation via Rental Market

In this subsection, I examine how farm size consolidation occurs—whether through land sales (ownership consolidation) or through the rental market (operational consolidation). Historically, the land sales market in developing countries has been largely inactive due to cultural norms that discourage selling inherited land (Foster and Rosenzweig, 2022). Consistent with this, table 10 shows that salinity intrusion has no significant effect on either total land ownership or the Gini coefficient of land ownership at the village level. This implies that most consolidation likely occurs via the rental market.

The rental market can facilitate both allocative efficiency and consolidation. If rental market consolidation is occurring, we would expect to see (i) fewer households renting in land and (ii) a higher amount of land rented conditional on positive renting. Table 11 supports this: columns 1 and 2 show a 62 percent decline in the share of households that rent in land in high-salinity areas, while columns 5 and 6 show a 100 percent increase in the amount of land rented per renter.

A threat to identification is the possibility of pre-existing differences in rental market activity across regions. Table 12 rules this out by showing no difference in housing rental

activity between the tidally active and mature delta areas. Together, these results provide strong evidence that rental market consolidation plays a crucial role in enabling farmers to reach the scale required for adaptation to salinity intrusion.

5.5 Frictions from Religious Fragmentation

An important friction impeding land consolidation in response to climate-induced salinity intrusion stems from challenges in enforcing land rental contracts across religious groups. In coastal Bangladesh, where both Muslim and Hindu communities have historically coexisted, land fragmentation implies that rental contracts often need to be executed between members of different religious communities. Given that land ownership is spatially fixed, reallocation through the rental market is unavoidable for achieving the scale necessary for aquaculture adaptation. However, cross-religious rental transactions are potentially fraught with higher enforcement costs and trust deficits.

Local political leaders, who often play an informal role in mediating land disputes and contract enforcement, may face conflicting incentives. On one hand, they have electoral motives to remain impartial in religiously diverse settings to secure votes from both Muslims and Hindus. On the other hand, in less diverse areas, there may be fewer social or political costs associated with favoring one group over another, which can undermine contract enforcement for inter-religious rentals.

Empirical evidence supports the importance of religious diversity in mitigating these enforcement frictions. The analysis uses a Religious Diversity Index—defined as $(1 - (X_v^2 + Y_v^2)) \times 100$, where X_v and Y_v are the shares of Muslim and Hindu populations in village v — with higher values indicating greater diversity and presumably lower bias in local governance. To address endogeneity concerns (e.g., that recent aquaculture expansion may have caused migration and changed religious composition), the study instruments current diversity with its historical level from the 1961 census.

The results in table 14 show that religious diversity significantly amplifies the extent land reallocation to aquaculture in response to saltwater intrusion. Specifically, villages above the median level of historical religious diversity saw an additional 28.8 decimals of aquaculture land per household in high-salinity zones, representing a 100% incerase over and above the average treatment effect.

However, one might be concerned that religious diversity might affect aquaculture productivity through other direct effects such as improved public goods provision. But, results in table 15 reveal that historical religious diversity does not predict access to public or private goods such as concrete housing, sanitary toilets, or electricity, supporting the validity

of the exclusion restriction. Furthermore,table 16 provides strong evidence all across the board that more religious diversity results in higher rental market activities. Together, these findings indicate that weak contract enforcement between religious groups is a substantial barrier to climate adaptation through land market consolidation.

5.6 Frictions from Land Fragmentation

A major barrier to adaptation via land reallocation is the high degree of land parcel fragmentation prevalent in many parts of rural Bangladesh. When landholdings are divided into numerous small and spatially scattered plots, consolidating enough land to meet the scale requirements for aquaculture becomes substantially more difficult. This constraint is particularly binding for aquaculture, which requires larger contiguous areas due to its higher fixed costs and scale economies.

Table 17 provides empirical evidence that land fragmentation significantly dampens the adaptive response to salinity. While households in high-salinity areas (> 12 dS/m) increase aquaculture land by an average of 40.46 decimals, this response is attenuated by 22.48 decimals in villages where land fragmentation is above the median. This negative interaction effect is statistically significant at the 10% level, indicating that higher fragmentation imposes substantial consolidation frictions even in the presence of strong climatic incentives to adapt. These findings highlight the importance of institutional and market mechanisms that facilitate land aggregation in fragmented landscapes to enable effective climate adaptation.

6 Conclusion

This paper examines whether gradual, climate-induced shifts in land productivity can overcome long-standing frictions in land markets and enable structural adaptation in agriculture. Using a natural discontinuity in soil salinity at the boundary between the tidally active and mature deltas in coastal Bangladesh, I identify the causal effects of salinity intrusion on land use, farm size, and land market activity.

I find that high salinity levels — above the threshold at which crops become unviable — induce a large reallocation of farmland from crop cultivation to brackish-water aquaculture. This transition is accompanied by significant increases in average farm size and farm size inequality, reflecting the scale-intensive nature of aquaculture. These changes occur not through land sales, which remain stagnant, but through the rental market: fewer households rent in land, but those who do rent substantially more, suggesting consolidation via operational rather than ownership channels.

The extent of adaptation, however, depends critically on underlying market frictions. Villages with higher religious diversity — which likely improves cross-group contract enforcement — show significantly greater reallocation. In contrast, villages with higher land fragmentation experience substantially less consolidation, even under strong environmental pressure.

Together, these findings demonstrate that climate change can reshape land markets and production structures, but the speed and effectiveness of adaptation depend on institutional and spatial constraints. Rental markets can serve as important vehicles for adaptation when land sales are constrained, but their functioning is highly sensitive to enforcement and transaction frictions.

Looking forward, policy efforts that improve land rental market efficiency — such as stronger contract enforcement, platforms for land pooling, and mechanisms for resolving cross-household disputes — may play a critical role in enabling rural households to adapt to environmental change. As climate risks intensify in vulnerable regions, understanding and strengthening the market channels through which structural transformation occurs will be essential for both adaptation and long-run agricultural development.

Appendix

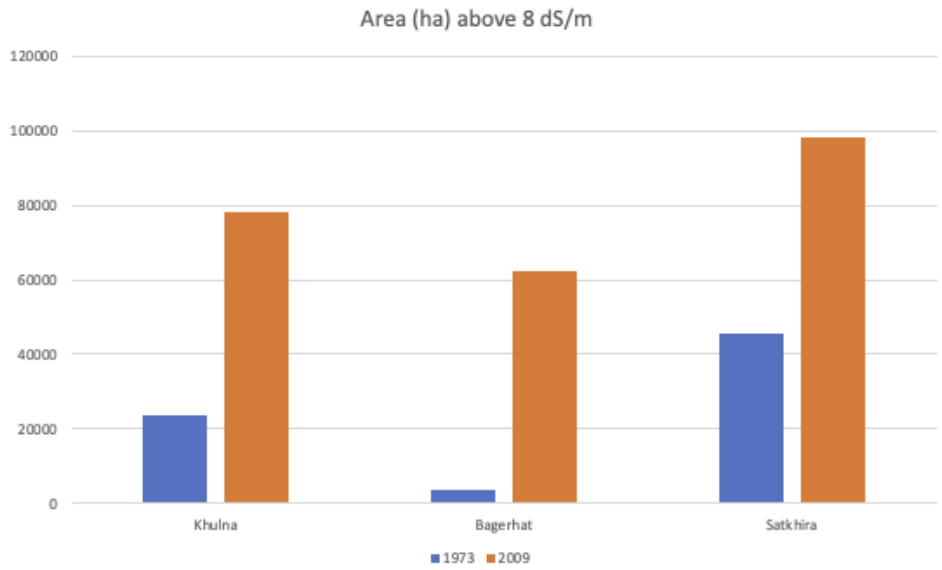


Figure 1: Trend of Salinity in the Study Area

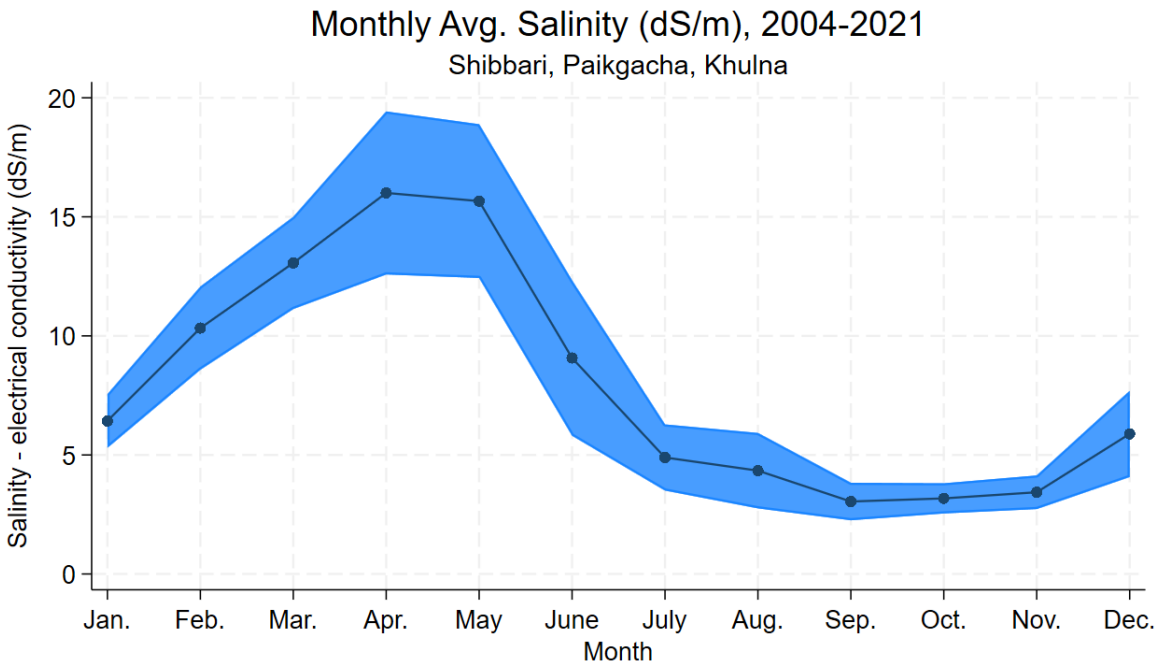


Figure 2: Seasonality in Soil Salinity Levels



Figure 3: Aquaculture Farms

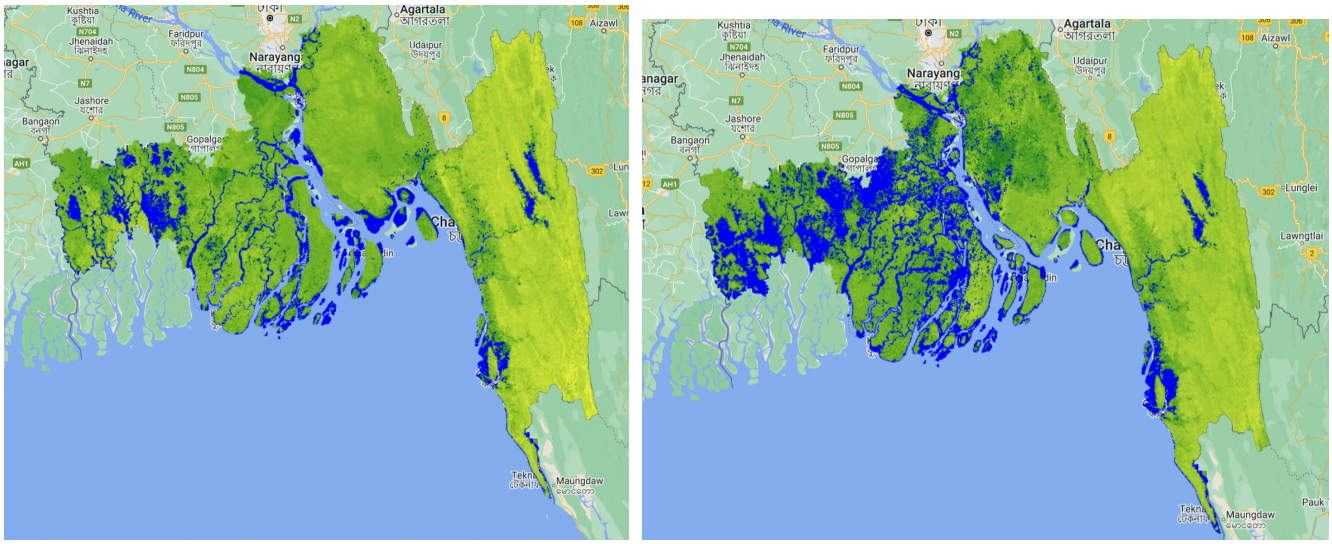


Figure 4: Landsat 5 Images of Dry Season Aquaculture: 1988 vs 2009

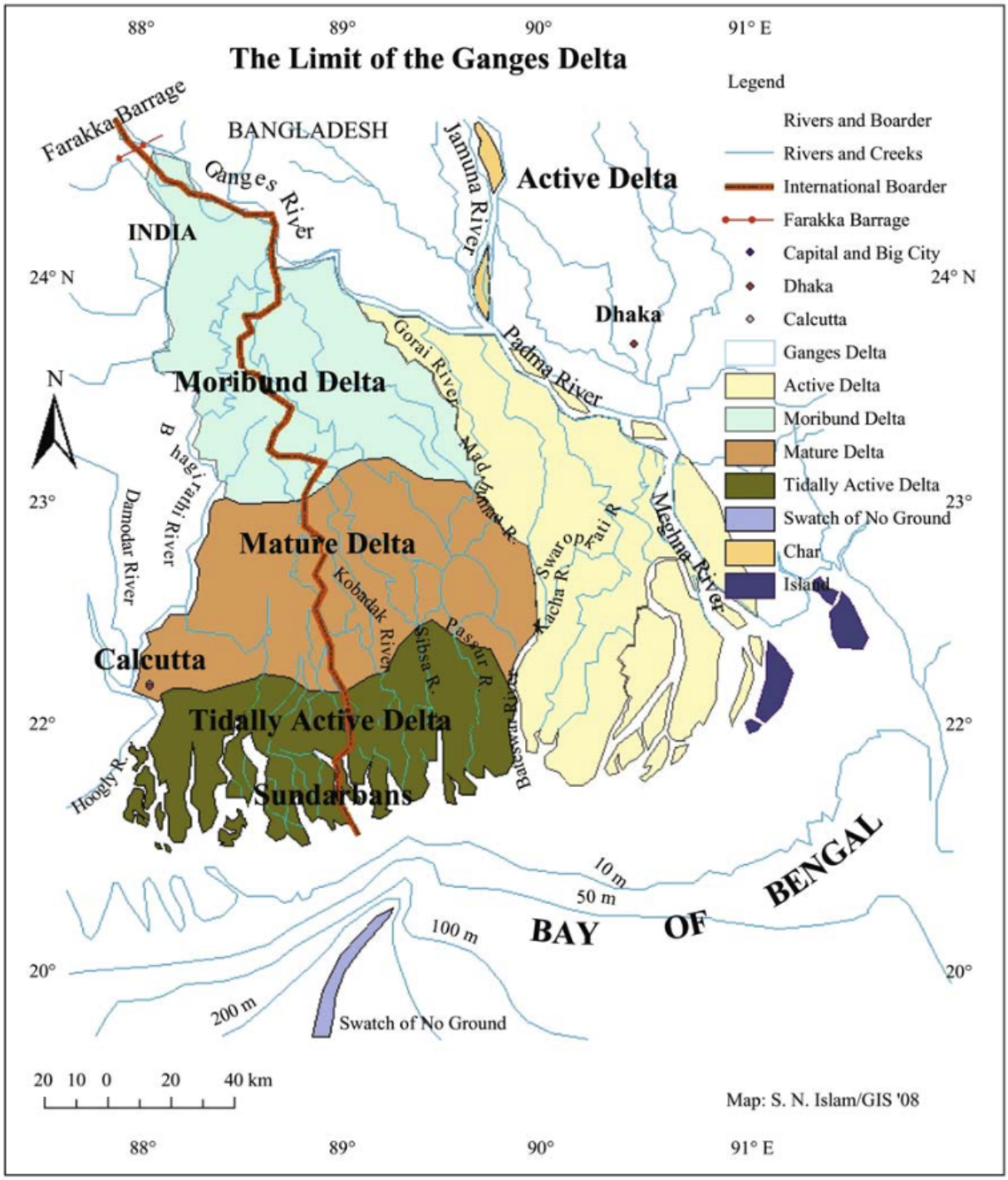


Figure 5: Tidally active delta

The above map shows division of the Bengal Delta into active, tidally active, mature and moribund deltas. Source: Islam and Gnauck (2008)

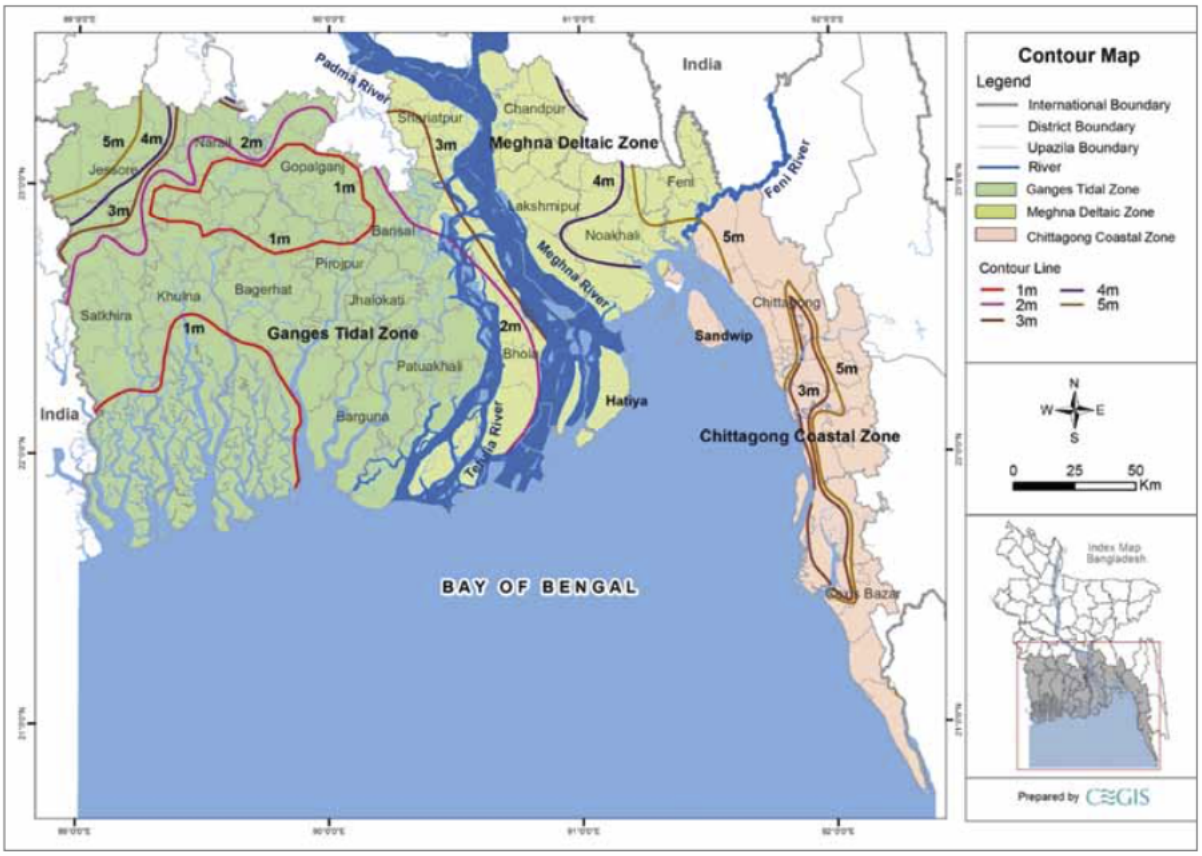


Figure 6: Coastal Contour Map
Source: Climate Change Cell (2016)

Salinity range (dS/m)	Frequency	Percent
0 to 4	924	36.89
4.1 to 8	228	9.10
8.1 to 12	292	11.66
12.1 to 16	667	26.63
Above 16	394	15.73
Total	2505	100

Table 1: Range of Salinity Across Study Villages

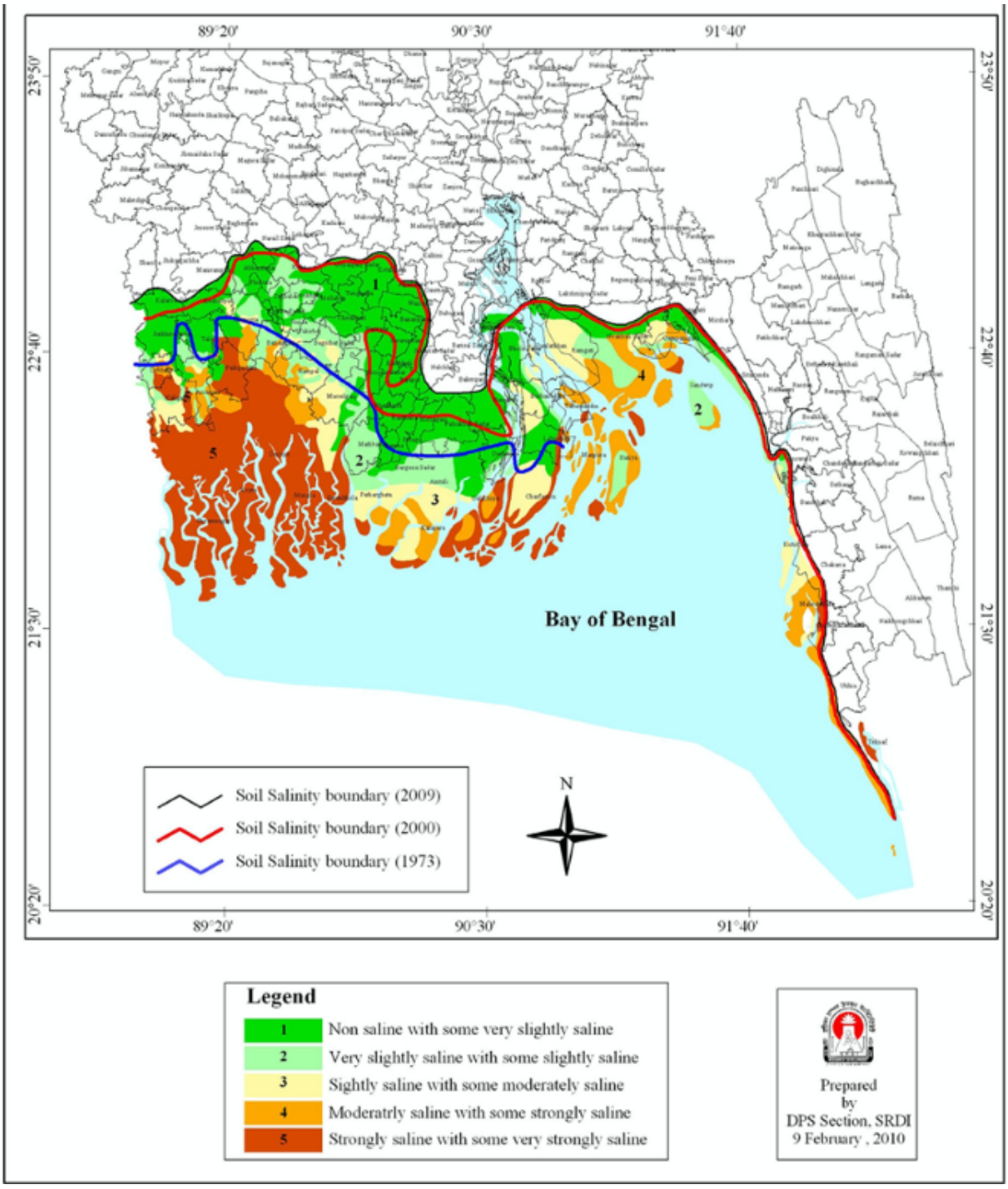


Figure 7: Soil Salinity Map

The above map shows the soil salinity level of the coastal areas. The extreme high salinity zone in south-west coast almost coincides with the tidally active delta. Source: Soil Resources Development Institute (2010)

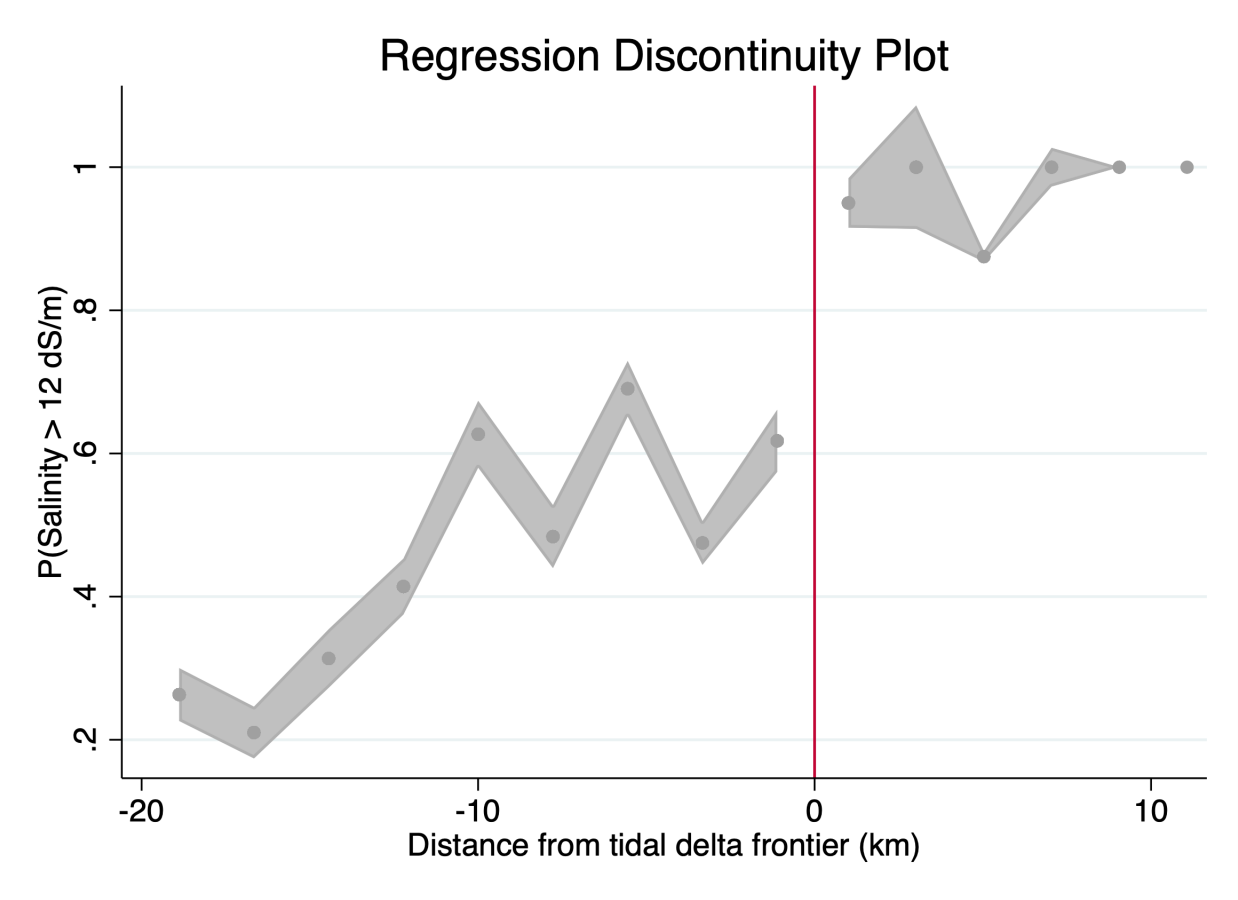


Figure 8: Regression Discontinuity Plot: First Stage

Variables	Mean	SD	Median
Household Size	5	2	4
Homestead Size	6	9	5
Owned Land	88	210	17
Rented Land	25	111	0
Leased out Land	21	110	0
Net Cultivated Land	68	164	8
Net Irrigated	27	83	0
Fallow Land	1	19	0
Temporary Crop Land	60	156	0
Land in Aquaculture	20	123	0
Observations	1263118		1263118

Land variables are in decimals (1 acre=100 decimals)

Table 2: Summary Stats of Agricultural Census 2008

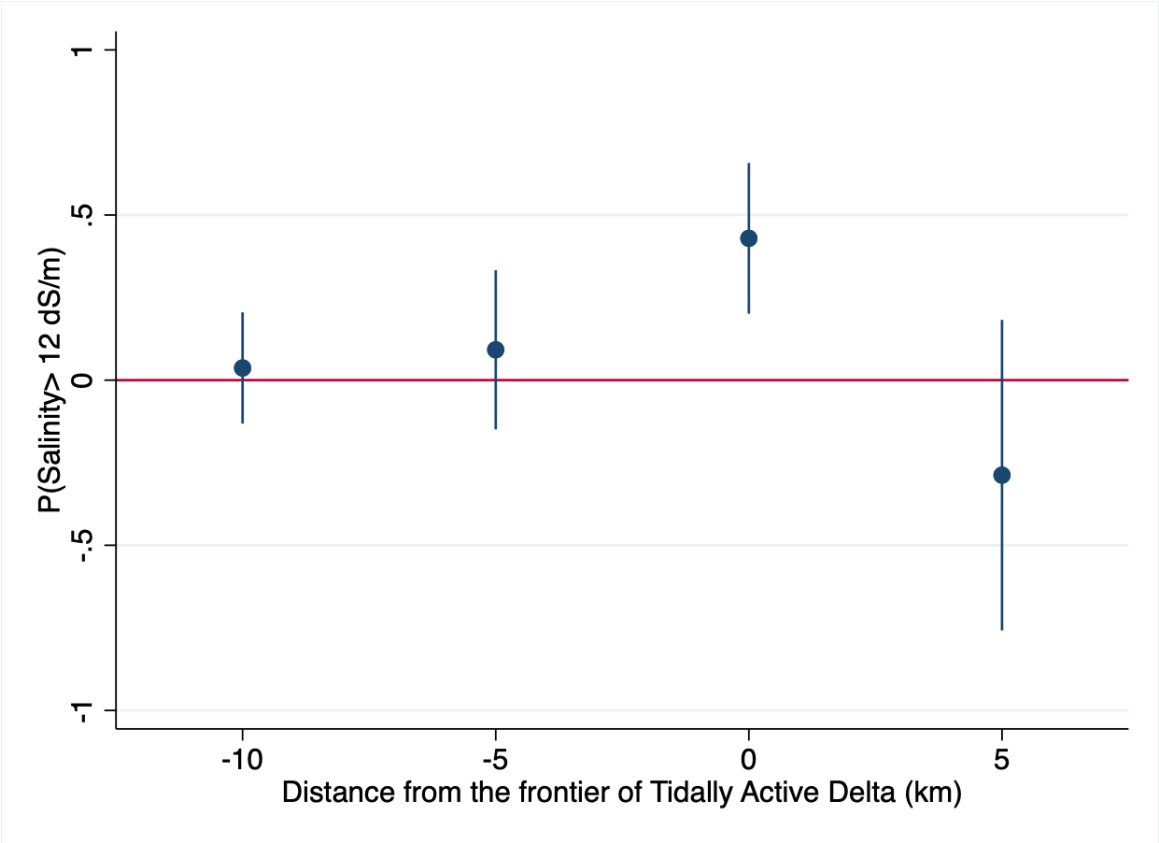


Figure 9: Placebo Cutoff: First Stage

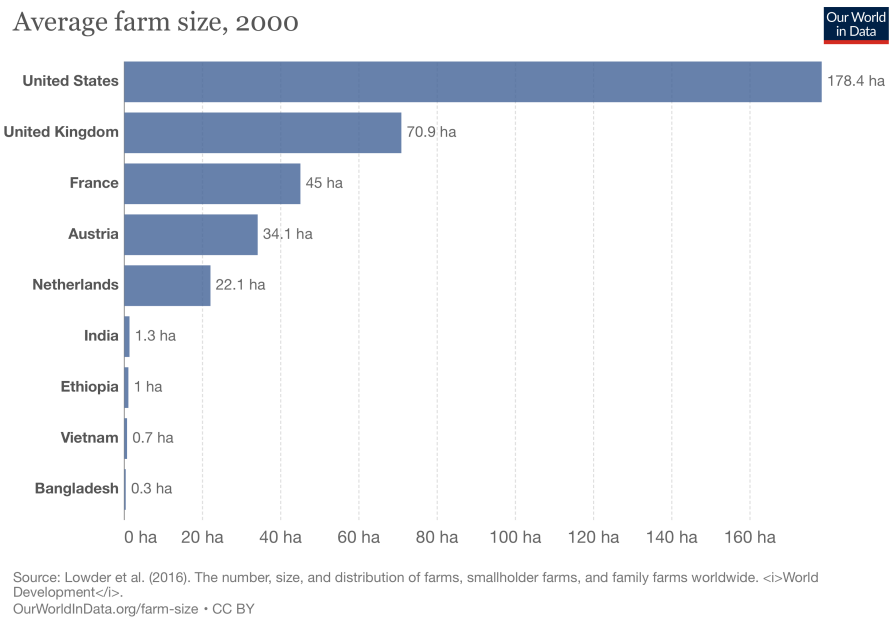


Figure 10: Farm Size Across Countries

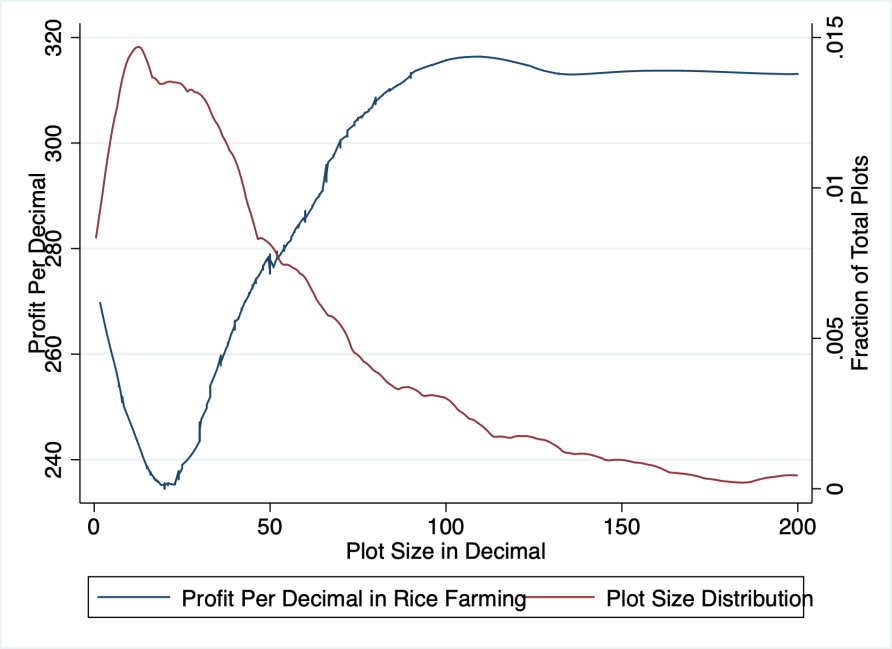


Figure 11: Misallocation in Agriculture

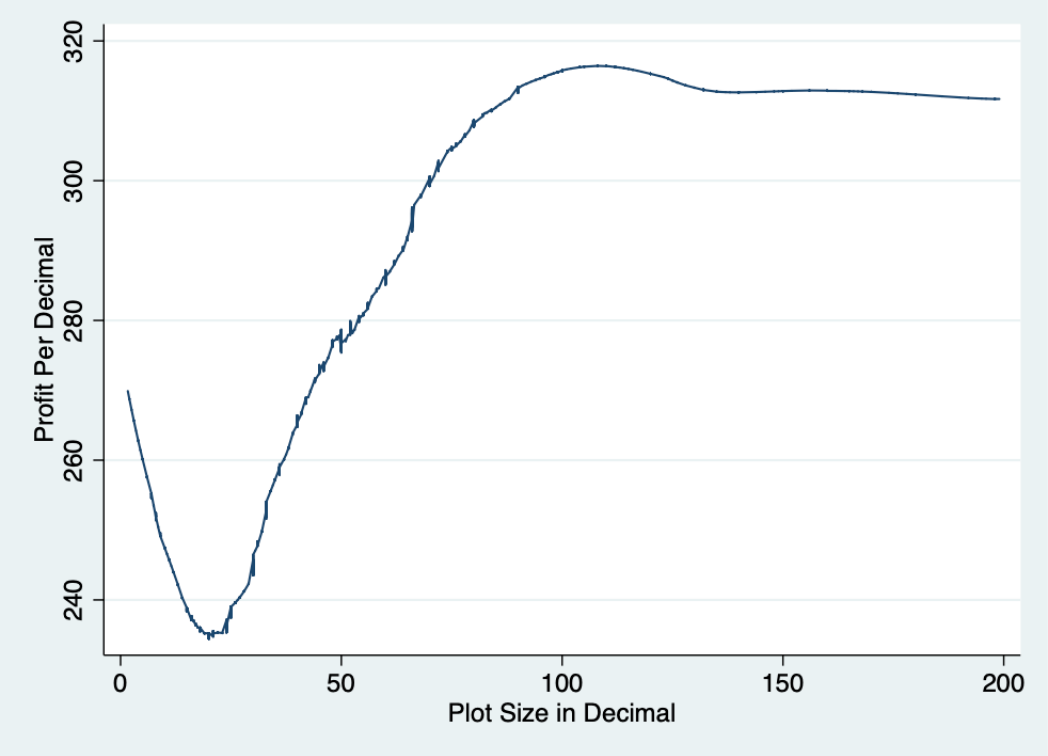


Figure 12: Productivity vs. Scale in Agriculture

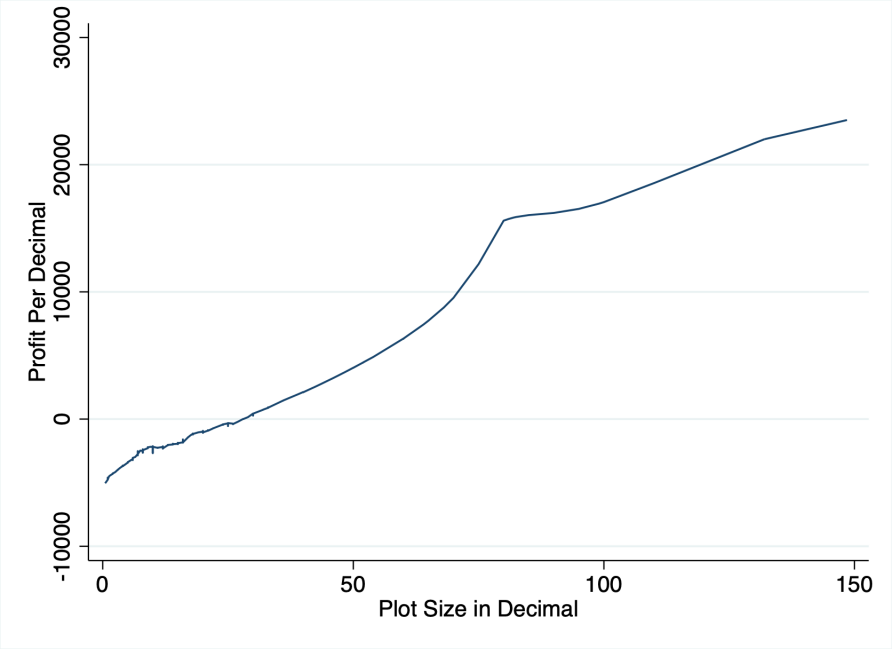


Figure 13: Productivity vs. Scale in Aquaculture

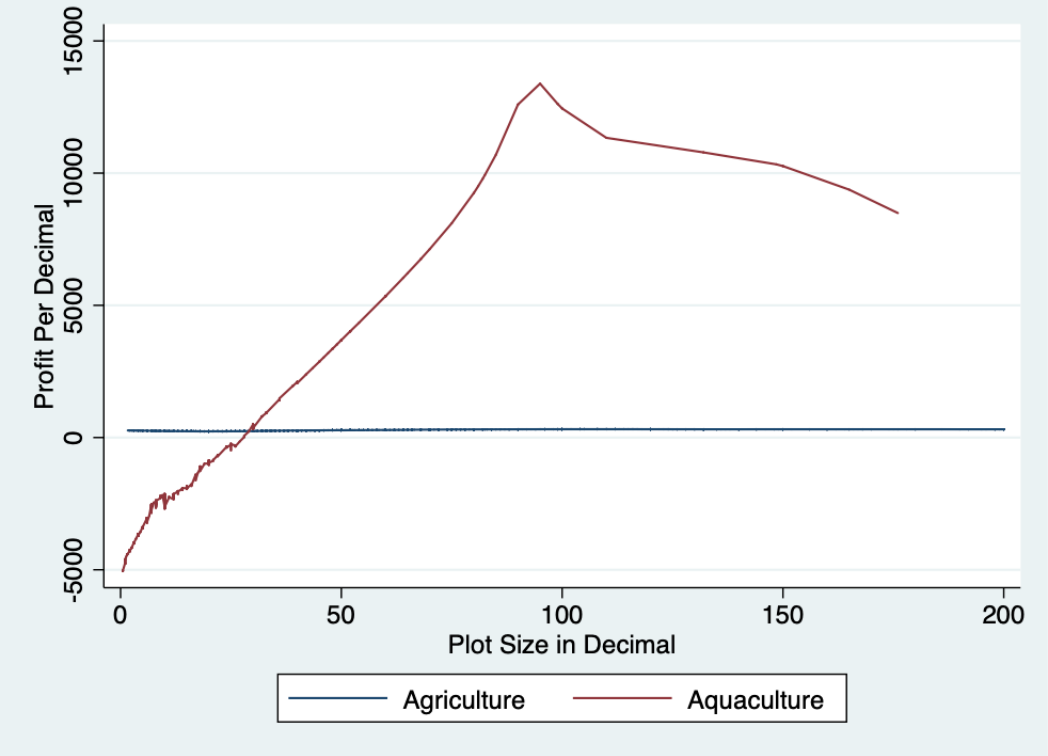


Figure 14: Scale Comparison: Agriculture vs. Aquaculture

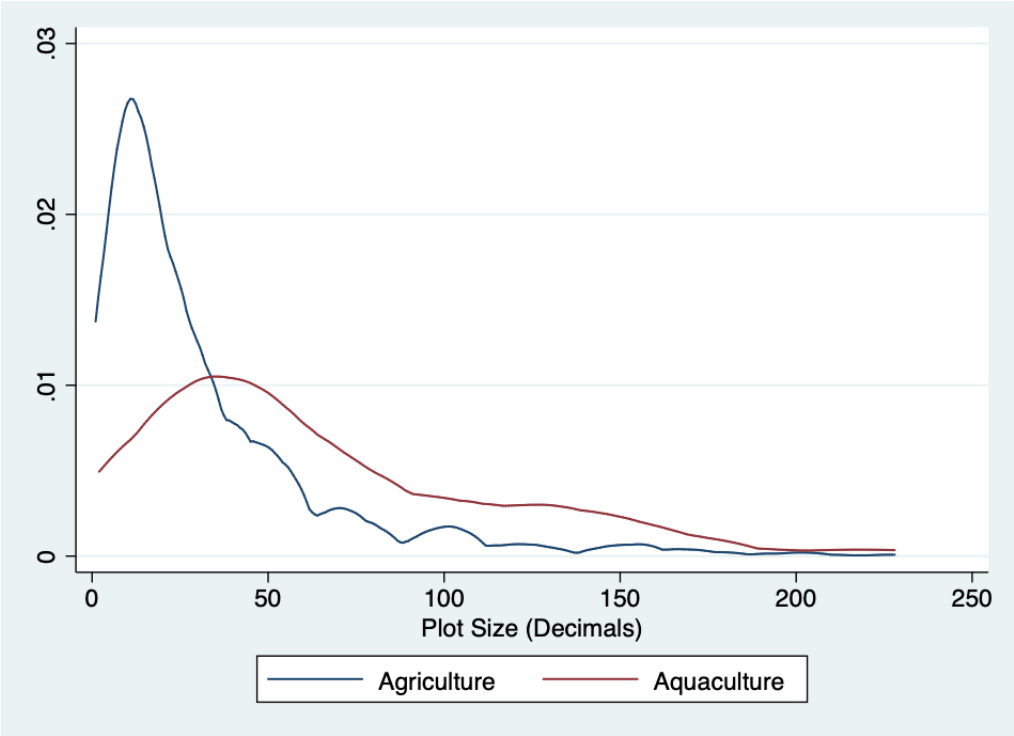


Figure 15: Plot Size Comparison: Agriculture vs. Aquaculture
Data Source: Bangladesh Integrated Household Survey, 2011

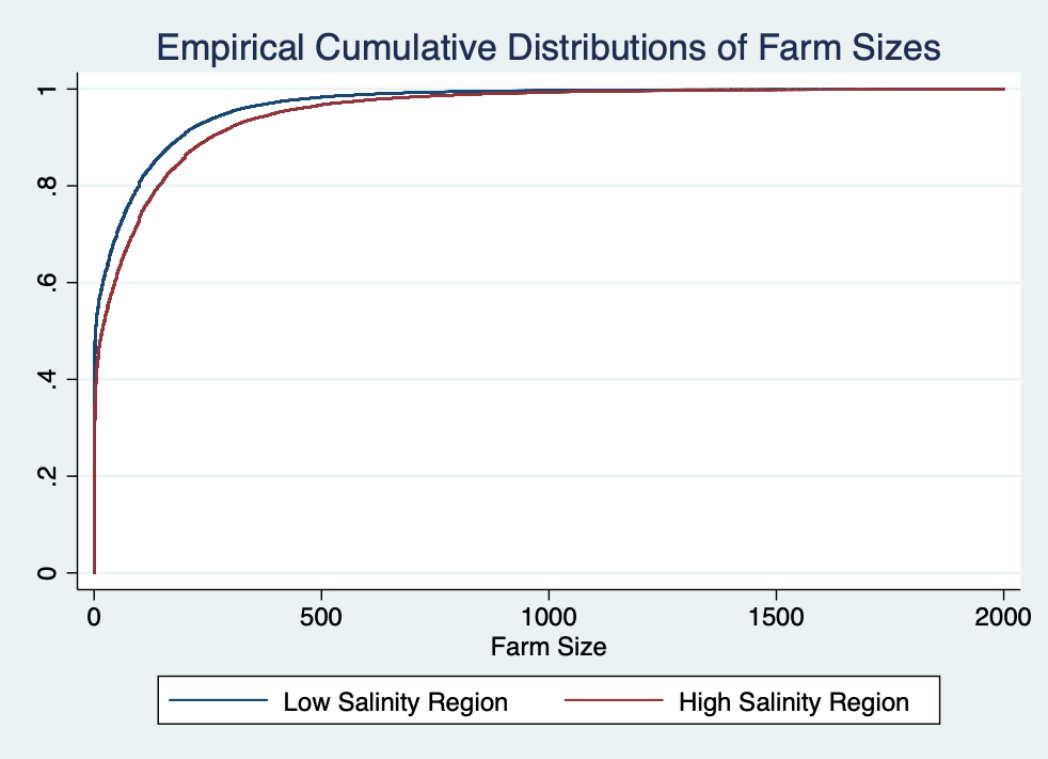


Figure 16: Farm Size Distribution: High vs. Low Salinity

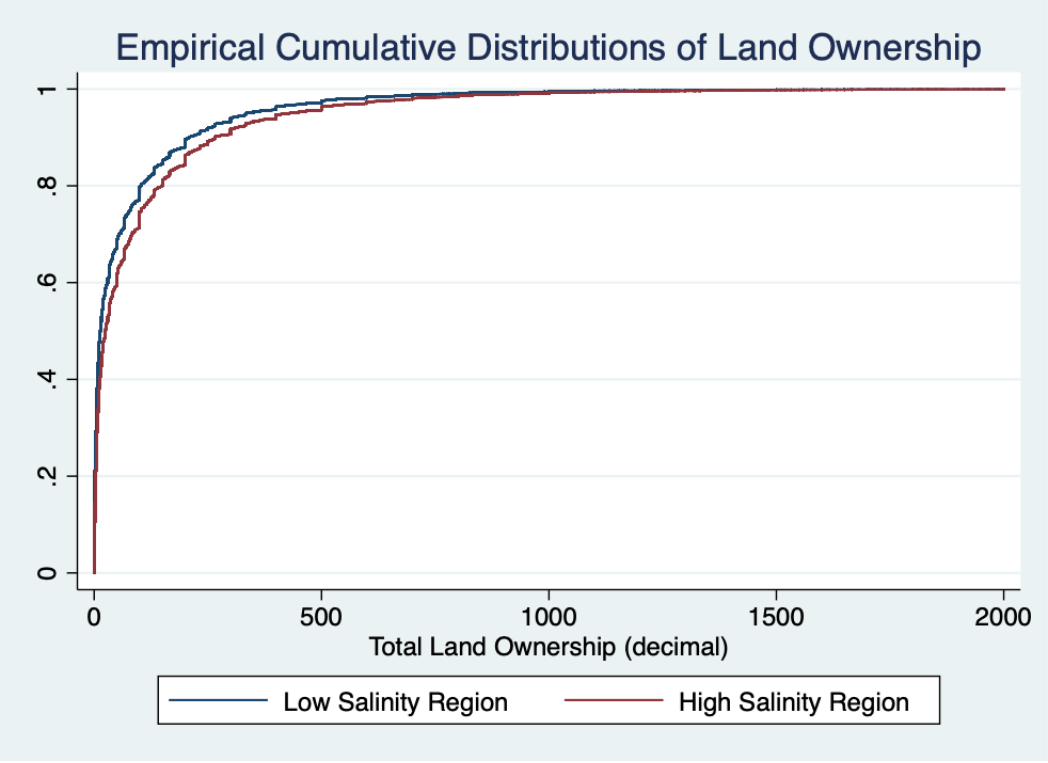


Figure 17: Ownership Distribution: High vs. Low Salinity

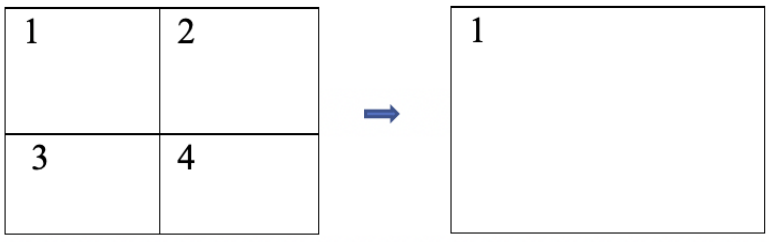


Figure 18: Consolidation Visual

	$1\{Salinity > 12 dS/m\}$	
	RD First Stage	IV First Stage
	(1)	(2)
$1\{Tidal\ Delta\}$	0.429**	0.604***
	(0.119)	(0.0399)
F-Stats	17	228
Longitude quartile FE	Yes	No
District FE	No	Yes
N	146	2505
Control Mean	0.38	0.38
MSE Optimal BW	6	NA

Standard errors in parentheses are clustered at village level

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

Table 3: Increased Probability of High Salinity within Tidal Delta

	Amount of Land in Aquaculture			
	Fuzzy RD		2SLS	
	(1)	(2)	(3)	(4)
$1\{Salinity > 12\, dS/m\}$	50.68**	52.27***	35.93***	31.79***
	(20.57)	(19.50)	(8.602)	(7.834)
Longitude quartile FE	Yes	Yes		
District FE			Yes	Yes
Farm Controls	No	Yes	No	Yes
Control Mean	19	19	19	19
Control Mean Farm Size	62.40	62.40	62.40	62.40
Treatment Mean Farm Size	93.19	93.19	93.19	93.19
N	113146	113146	1166498	1166498
MSE Optimal BW	6	6	NA	NA

Standard errors in parentheses are clustered at village level

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

Table 4: Effect of Salinity on Land Allocation to Aquaculture

	Land in Aquaculture						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
RD Estimate	11.07	17.59**	22.19**	22.21***	19.63**	16.54**	13.83*
	(8.668)	(8.508)	(8.538)	(8.342)	(7.891)	(7.509)	(7.222)
Longitude-quartile FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Farm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Manual BW (km)	3.25	3.75	4.25	4.75	5.25	5.75	6.25
Effective N	90198	102314	110793	124227	136603	147833	149651
Control Mean	28.510	28.510	28.510	28.510	28.510	28.510	28.510
	(3.899)	(3.899)	(3.899)	(3.899)	(3.899)	(3.899)	(3.899)

Standard errors in parentheses are clustered at village level

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

Table 5: Robustness to Bandwidth Selection

	Temporary Crops	Bamboo Clumps	Permanent Trees
	(1)	(2)	(3)
RD_Estimate	-17.20**	0.0119	-0.446
	(8.241)	(0.0997)	(0.769)
Longitude-quartile FE	Yes	Yes	Yes
Farm controls	Yes	Yes	Yes

Standard errors in parentheses are clustered at village level

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

Table 6: Robustness to Placebo Outcomes

	Rabi Season		Kharif Season
	Rice	Wheat	Rice
	(1)	(2)	(3)
$1\{Salinity > 12\, dS/m\}$	-34.25***	-0.852***	12.70
	(3.158)	(0.142)	(10)
District FE	Yes	Yes	Yes
Control Mean	40.63	1.10	40
N	1166498	1166498	1166498

Standard errors in parentheses are clustered at village level

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

Table 7: Effect of Salinity on Land Allocation to Rice Farming by Season

	Rabi Season Rice Cultivation	
	Tolerant Rice	Sensitive Rice
	(1)	(2)
$1\{Salinity > 12\, dS/m\}$	-6.373***	-27.88***
	(1.073)	(3.596)
District FE	Yes	Yes
N	1166498	1166498

Standard errors in parentheses are clustered at village level

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

Table 8: Effect of Salinity on Land Allocation to Dry Season Rice Farming by Variety

	Farm Size		Gini of Farm Size	
	(1)	(2)	(3)	(4)
$1\{Salinity > 12\, dS/m\}$	33.10***	20.33***	0.166***	0.114***
	(8.994)	(5.153)	(0.0251)	(0.0155)
Owned Land		0.648***		
		(0.0106)		
Gini of Owned Land				0.899***
				(0.0219)
District FE	Yes	Yes	Yes	Yes
Control Mean	62.40	62.40	0.67	0.67
N	1166498	1166498	2505	2505

Standard errors in parentheses are clustered at village level

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

Table 9: Effect of Salinity on Farm Size

	Owned Land	Gini of Ownership
	(1)	(2)
$1\{Salinity > 12\, dS/m\}$	15.50	0.0497
	(10.25)	(0.0328)
District FE	Yes	Yes
Control Mean	78.85	0.74
N	1166498	2505

Standard errors in parentheses are clustered at village level

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

Table 10: Effect of Salinity on Ownership Consolidation

	$1\{Land\ Rented\ in > 0\}$		Land rented-in			
			Full Sample		Conditional Sample	
	(1)	(2)	(3)	(4)	(5)	(6)
$1\{Salinity > 12\ dS/m\}$	-0.218***	-0.216***	0.698	-0.568	72.45***	50.56**
	(0.0466)	(0.0460)	(6.429)	(6.620)	(25.77)	(20.10)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Farm Controls	No	Yes	No	Yes	No	Yes
N	1166498	1166498	1166498	1166498	373006	373006
Control Mean	0.35	0.35	20.27	20.27	60.23	60.23

Standard errors in parentheses are clustered at village level

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

Table 11: Evidence on Consolidation through Rental Market

	$1\{Rented\ House\}$
	(1)
$1\{Tidal\ Delta\}$	-0.0390
	(0.0472)
District FE	Yes
N	1371460

Standard errors in parentheses are clustered at village level

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

Table 12: Evidence on No Differential Rental Behavior in Housing Market

	$1\{Land\ Leased\ Out > 0\}$	Land Leased Out	
		Full Sample	Conditional Sample
	(1)	(2)	(3)
$1\{Salinity > 12\ dS/m\}$	-0.0115	-4.405	-9.947
	(0.0462)	(6.361)	(15.70)
District FE	Yes	Yes	Yes
N	1166498	1166498	181113

Standard errors in parentheses are clustered at village level

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

Table 13: Evidence on No Change in Long Run Land Supply

	Land in Aquaculture	
	(1)	(2)
$1\{Salinity > 12\, dS/m\}$	23.64**	26.26**
	(9.308)	(9.759)
$1\{Salinity > 12\, dS/m\}$*$1\{Above\ Median\ Diversity\}$	22.62**	
	(10.60)	
$1\{Salinity > 12\, dS/m\}$*$1\{Above\ Median\ Diversity\ in\ 1961\}$		28.76**
		(10.76)
District FE	Yes	Yes
N	1166439	1166498
Cluster	Village	Sub-district

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

Table 14: Effects of Religious Fragmentation

	$1\{Concrete\ House\}$	$1\{Sanitary\ Toilet\}$	$1\{Electricity\}$
	(1)	(2)	(3)
$1\{AboveMedianDiversity\}$	0.0422	-0.000736	0.0198
	[0.42]	[1.00]	[0.62]
Mean	0.62	0.28	0.49
District FE	Yes	Yes	Yes
N	1371460	1371460	1371460

P-values from wild bootstrap inference with clustering at Sub-district level in brackets

Table 15: Exclusion Tests for Diversity Effects

	$1\{Land\ Leased\ Out > 0\}$	Land Leased Out		$1\{Land\ Rented\ in > 0\}$	Land Rented-in	
		Full Sample	Conditional		Full Sample	Conditional
	(1)	(2)	(3)	(4)	(5)	(6)
$1\{Above\ Median\ Diversity\}$	0.00308***	2.849***	16.42***	-0.0321***	2.184**	12.33***
	(0.000671)	(0.791)	(3.497)	(0.00869)	(0.954)	(3.177)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
N	1166439	1166439	181107	1166439	1166439	372965

Standard errors in parentheses are clustered at the village level

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

Table 16: Effects of Religious Diversity on Rental Markets

	Amount of Land in Aquaculture
	(1)
$1\{Salinity > 12\, dS/m\}$	40.46***
	(7.660)
$1\{Salinity > 12\, dS/m\}$*$1\{Above\ Median\ Land\ Fragmentation\}$	-22.48*
	(12.67)
Mean	19
District FE	Yes
N	1166498

Standard errors in parentheses are clustered at village level

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

Table 17: Effects of High Land Fragmentation on Adaptation

References

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