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Impact Evaluation of the Bohol Irrigation Project (Phase 2) in the Republic of the Philippines

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Preface

Japan‘s ODA charter revised in 2003 shows Japan‘s commitment to ODA evaluation under the section ―Enhancement of Evaluation", stating the importance of objective evaluation on the outcome of ODA projects.

Recently in the context of increasing concern on development outcomes, in order to implement more effective and efficient assistances, impact evaluation that precisely measures change that occurs as the result of an intervention or project implementation is beginning to receive more attention. JICA has been working on promoting the utilization of impact evaluation methods.

The volume shows the results of the impact evaluation of an ODA Loan project, Bohol Irrigation Project (Phase 2) in the Republic of the Philippines. This evaluation was conducted by the International Rice Research Institute. The result drawn from the evaluation will be shared with the JICA‘s stakeholders for the sake of improving the quality of ODA projects.

Lastly, deep appreciation is given to those who have cooperated and supported the creation of this volume of evaluation.

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Disclaimer

This volume of evaluation shows the result of impact evaluations made by external evaluators. The views and recommendations herein do not necessarily reflect the official views and opinions of JICA.

Minor amendments may be made when the volume is posted on JICA's website.

Executive Summary

This report evaluates the impact of the Bohol Irrigation Project (Phase 2) and draws implications for a greater and sustainable impact for the future. [1] The irrigation system is a gravity irrigation system consisting of a reservoir dam (Bayongan dam), a main canal, secondary canals or laterals, turnouts, and farm ditches. This setup is different from other ordinary systems in the country in that all canals and laterals are lined, every turnout has a concrete structure, and most of the turnouts have a steel spindle gate in the system. Similar to other systems, the farm ditches are earth canals. The system started its operation in May 2008 with an expected service area of 4,140 ha as identified in the feasibility study conducted in 1985. The irrigable area identified by the National Irrigation Association (NIA) and actual irrigated area have been increasing since the start of operation, and as of November 2011, the annual official record shows that the former had reached to 3,295 ha. and the latter was 2,644 ha. The un-irrigated area includes the area that farmers did not irrigate regardless of the availability of irrigation water. The system is managed by NIA in collaboration with the farmers' management unit called the irrigator associations (IAs), which are further divided into multiple turnout service areas (TSAs). A TSA involves a group of farmers who share a turnout for their irrigation. NIA takes care of the operation and maintenance of the facilities from the dam to the lateral level. The lower-level facilities, such as turnouts and farm ditches, are under the responsibility of the IAs and the TSAs. The IA's major role is to take care of the irrigation rotation among the TSAs and the TSAs are in charge of the construction, operation, and maintenance of the farm ditches. Before the project, the study site relied fully on rainfall and natural creeks for irrigation and rice, cassava, sweet potatoes, coconuts, and mangoes were grown. This report aims to show changes from such rainfed farming to irrigated farming brought about by the large irrigation infrastructure project.

To evaluate the impact of a large-scale infrastructure project in a comprehensive and statistically reliable manner, we have developed our approach with the following features.

- A counterfactual case was selected on the basis of similarities in hydrological, agronomic, and socioeconomic aspects, rather than reliance on statistical technique to identify samples.
- The report included multifaceted aspects of the irrigation impact.
- The survey period was set long enough to capture differential impacts under weather shocks.
- The impacts are disaggregated over different groups to examine the equitable distribution of project outcomes.

[1] Bohol Irrigation Project (Phase 2) consists of the construction of Bayongan Irrigation System and the extension and rehabilitation of Capayas Irrigation System. This study is to evaluate the impact of Bayongan Irrigation System only.

With these features, we examined (1) the impact of the project, (2) the equity issues within the project, and (3) the effect of volumetric pricing on water savings. The findings are summarized below.

(1) Impact of irrigation project

- The irrigation project has transformed rice farming from a traditional to a high-input-high-return system. Over the survey period, the average paddy yield of irrigated rice farmers was about twice as high as that of rainfed rice farmers (2.4 t/ha per season of dry paddy vs 1.2 t/ha per season). As to inputs, irrigated rice farmers used about 1.5 times more chemical fertilizer than did rainfed rice farmers and they have also started to use hybrid rice varieties.
- This transformation has resulted in a higher rice income of irrigated farmers than the counterfactual rainfed rice farmers (about 2.4 times higher over the seasons).
- Another benefit of irrigation was the reduction in risk against drought. The irrigated rice farmers‘ income did not go down during the drought season (2009 November–2010 April) as much as the rainfed farmers‘ income did. However, in the project area, even the irrigated rice farmers suffered from the negative shock of flooding (2010 November–2011 April).
- As a result of these changes, irrigated rice farmers were able to have higher and more stable income (except during the flood season), which contributed to faster growth of household assets. For example, the irrigated rice farmers‘ total asset value per capita (a long-term welfare indicator) was 1.6 times higher than that of rainfed rice farmers in the last survey season,
- However, it is worth noting that rainfed rice farmers had non-agriculture income sources and they earned higher income from these sources; this made the income gap between the two groups of farmers smaller.

(2) Equitable water access and project outcomes among irrigated rice farmers

- We compared the differences in water access and in project outcomes between different groups of farmers. Note that this attempt is an examination of ex-post equity, which does not necessarily indicate whether the impacts (or changes) are equal between groups. In this attempt, we did not find any statistical difference in water access as well as in key outcomes (such as yield, income, and asset value, etc.) along the main canal. This indicates that the main canal is properly designed and constructed to the extent that the system is supposed to irrigate the current service area (about 2,600 ha) and that NIA has been properly maintaining and managing the facilities they are supposed to take care of. Also, we did not find strong evidence of differences in water access and outcomes among small landholders, asset non-rich farmers, non-owner cultivators, and female-headed households.

- Meanwhile, we did find disadvantages in terms of water access and yield among farmers on the downstream portion of the laterals (secondary canals).
- Differences in water access and outcomes were found also within a TSA: upstream parcels achieved higher rice income per ha by taking advantage of the hydrological privilege, particularly during drought season.
- Although statistical significance was weak, it is still better to pay attention to a possible disadvantage among land reform beneficiaries because our data showed that their water access was slightly worse than that of others possibly because of their weak social position relative to their ex-landlords. who sometimes try to occupy irrigation water as their vested interest.

Regarding the disadvantage of the downstream area along the laterals, seepage loss cannot be the reason for the water shortage in the system with lined canals and laterals. Rather, this problem is mainly attributed to a failure in equitable water rotation among TSAs along the laterals. Hence, the strengthening of IAs in order to facilitate a stricter water rotation is important. For this purpose, we may draw lessons from JICA‘s experience in the rehabilitation of the Bago River Irrigation System in Negros, where downsizing of IA on the basis of actual water boundary significantly improved water rotation and reduced water conflicts among the TSAs. In fact, the IA reforms initiated recently by NIA in this system is in line with the Bago experience and could thus contribute to the improvement of the water rotation scheme.

Besides, note that addressing infrastructure-related problems is an important factor in the implementation of strict rotation by IA because rotation may not be done effectively if control of water flow is difficult. We identified two kinds of infrastructural problems in the system: malfunctioning turnouts and (2) malfunctioning farm ditches. Our data indicated that about 6% of the total sample TSAs have the former and 20% face the latter.[2] Since the latter is more common in the system under study, repair work by TSA is crucial. In this case, collaboration between TSAs and NIA is still important as the lack of knowledge on hydrology affects the ditch design and the lack of manpower and budget for ditch excavation and lining becomes main bottlenecks. In line with this, NIA started the validation of farm ditch lining with the agency‘s own budget (a total of 23 km of lining with PhP46 million in 2012). This would facilitate stricter water rotation.

As to water allocation within a TSA, our analyses show that absence of infrastructural problems is important to ensure better management of TSA. Otherwise, the TSAs would not have the incentive to manage their service area. Under that condition, TSAs can

[2] The classification of the problems is based on the observations of water engineers hired for this evaluation study.

perform better if the members are located close to each other (regardless of the fact that they could come from different villages). In other words, a diverse composition of villages does not matter as long as the members are located close to each other. The location of turnouts and the associated boundaries of TSAs must be so designed to take this aspect into consideration.

(3) Impact of volumetric pricing

- As part of this project, we randomly introduced a volumetric pricing scheme (a bonus given for savings from a threshold level of water consumption but no penalty for overuse) to half of the TSAs. In comparison with the current pricing system (area-based system), we hypothesized that more water savings could be achieved through the group effort of TSAs.
- The results showed that, under the volumetric incentive scheme, the TSAs with no infrastructural problems of water control at the turnout level gradually reduced their water use, but this reduction was not statistically significant. The impact could have been significant if our pricing system provided not only a reward to water savings but also a penalty for overuse, or if we have set the reward rate higher.
- We also found that the ‗volumetric groups' saved water so much that they suffered yield losses during drought.

A lesson from this experiment is that volumetric pricing to TSAs with no infrastructural problems would be effective under a proper price level, and that training on safe water saving would be important to avoid the risk of yield reduction.

In short, the Bohol Irrigation Project (Phase 2) substantially improved the livelihood of the beneficiary farmers by enabling to earn higher and more stable income from rice production than the counterfactual rainfed rice farmers. To achieve equitable outcomes within the system, the role of IAs and TSAs is crucial. The performance of IAs and TSAs depends on the structure of the group. For example, IA management could be more effective if the IA coverage is small enough to be consistent with actual water boundary. TSA management would be better if the members of a TSA are geographically near each other. The existence of functioning farm ditches is likewise important in ensuring better performance of the IAs and TSAs. Hence, in line with the ongoing NIA reforms, continuous efforts to achieve the abovementioned conditions would further contribute to more equitable outcomes. Note, however, that since these conditions could be set at the cost of hydrological efficiency, we have to consider the net gain of doing so. Another means to guide farmers toward better water management is the use of a volumetric incentive that encourages water savings so that the water saved by some TSAs can be used by other water-deficit TSAs. This approach, however, can only be used when the infrastructure allows volume measurement and inflow control at the TSA level. Here, functioning farm ditches come into the picture again. Since there is a risk of yield loss due to extreme water savings, it is better to implement volumetric pricing along with training on safe water saving.

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Acronyms

AWD: alternate wetting and drying
BIS: Bohol Irrigation System
CARP: Comprehensive Agrarian Reform Program
IA: irrigators' association
ISF: irrigation service fee
NIA: National Irrigation Administration
TSA: turnout service area
TSAG: turnout service area group

Contents

1. Introduction

This report evaluates the impact of a JICA-funded irrigation development project and draws implications for a greater and sustainable impact for the future. An irrigation project is a kind of large-scale physical infrastructure project. To evaluate this kind of project in a comprehensive and statistically reliable manner, we have to deal with several methodological and conceptual issues.

First, we have to identify an appropriate counterfactual case. This issue is particularly challenging in the case of large-scale projects because it is not feasible to use a randomization approach.

Second, we have to identify the beneficiaries. Unlike other infrastructure projects such as road construction, it is relatively easy to identify the beneficiaries of an irrigation system because we can easily distinguish irrigation water users and non-users. This holds true as long as we focus on the direct benefits of irrigation.

Third, we have to identify a comprehensive set of impact indicators. Irrigation *per se* affects the agricultural productivity of newly irrigated plots. However, the influence of irrigation is not limited to the irrigated plot; it could change farmers' lives completely. Productivity improvement in newly irrigated plots would influence farmers' time allocation to other parcels as well as to non-agricultural activities. Furthermore, an increased demand for collective management may affect social ties and value systems of the farming community. In this regard, changes caused by the irrigation intervention comprise a multifaceted phenomenon. For a comprehensive impact assessment, we need to examine multiple indicators. Tracking the changes that occur from inputs to outputs as well as from a particular irrigated plot to the household's livelihood enables us to understand the mechanism through which impact would be realized.

Fourth, we have to set an appropriate survey period for impact measurement. A one-shot survey may not capture the impact of the irrigation project because an important benefit of irrigation is insurance against rainfall shocks.

Fifth, we have to resolve the equity issue. This is crucial because the impact of a project may differ among project beneficiaries. In the context of irrigation development, better water access by upstream farmers compared with downstream farmers represents an innate equity issue connected to a gravity irrigation system.

This report evaluates the Bohol Irrigation Project (Phase 2) in the Philippines. [3] In the evaluation, by properly designing primary data collection as well as by using secondary data and existing reports, we endeavor to address the abovementioned issues to

[3] Bohol Irrigation Project (Phase 2) consists of the construction of Bayongan Irrigation System and the extension and rehabilitation of Capayas Irrigation System. This study is to evaluate the impact of Bayongan Irrigation System only.

gain a better understanding of the changes in livelihood of poor and small farmers brought about by the irrigation project.

The rest of the report is organized as follows. Section 2 provides background information of the study area. Section 3 describes the methodology and data set. Section 4 presents the results of impact evaluation and also discusses how to make impacts more equitable and sustainable. Section 5 summarizes the major findings and draws lessons for future evaluation initiatives as well as for future irrigation projects.

2. Background of the Study Area

2.1. The Bohol Irrigation System

The Bohol Irrigation System (BIS) is located in the northeastern part of Bohol Island, about 50 km from the capital city of Tagbilaran (Fig. 1). BIS is an integrated three-dam system connected by diversion canals from Malinao Dam, Bayongan Dam, and Capayas Dam. Manilao and Capayas started operation in 1996 and 1993, respectively. Bayongan dam was constructed during Phase 2of the Bohol Irrigation Development Project and began operation in May 2008. A description of the entire BIS system is outlined in Table 1.

2.2. The Bayongan Irrigation System

The service area of the Bayongan system covers 14 villages in three municipalities (San Miguel, Ubay, and Tridnidad). Figure 2 shows the designed service area covered by Bayongan Dam identified in a feasibility study conducted in 1985; this is 4,140 ha. The actual service area of Bayongan Dam is smaller than that indicated because the system was not extended to about one-fourth of the area in the northwestern part (shown as Trinidad area in Figure 2). The system started operation in May 2008. Land leveling of non-paddy area for irrigation was being done at the time of this survey. The irrigable area identified by NIA and actual irrigated area have been increasing since the start of operation, and as of November 2011, the annual official record shows that the former had reached to 3,295 ha. and the latter was 2,644 ha. The un-irrigated area includes the area that farmers did not irrigate regardless of the availability of irrigation water. The features of the system are shown in Table 2 and the chronology of events is presented in Table 3.

The Bayongan Irrigation System is a typical gravity irrigation system consisting of a reservoir dam, a main canal, secondary canals or laterals, turnouts, and farm ditches.

Figure 3 illustrates the irrigation network of the system. Along 17.5 km of main canal, 15 laterals from Lateral A to Lateral O extend. Laterals from A to G are classified as upstream section and those from H to O are regarded to be downstream. Water flow between the two sections is controlled by a water gate. Turnouts are attached on the laterals or directly on the main canal, from which farmers bring water to the farm ditches. Each turnout has an ID code starting with the alphabet label of its lateral and the numerical number assigned from upstream to downstream along the lateral (for example, A-1, A-2, B-1, B-2, etc.). Among the turnouts on the main canal, BMC-1 to BMC-27, S-1, and S-1A are upstream and BMC-29 to BMC-45 are downstream. Farm ditches may consist of a few strata from the main, secondary, to tertiary ditches, depending on the size and topography of the area served by the turnout.

One distinction from other ordinary systems found in the country is that in here, all canals and laterals are lined by concrete, every turnout has a concrete structure, and most of the turnouts have a steel spindle gate. Meanwhile, similar to other systems, farm ditches are earth canals. The cost per hectare of the service area under Phase 2 of this project is about double that of an ordinary irrigation project in the country. At this cost, this system has attained the least water seepage along the canal and laterals and a better control of water inflow at the turnout.

2.3. Management structure (NIA, IAs, and TSAs)

BIS belongs to the Region 7 office of the National Irrigation Administration (NIA). The NIA Ubay office is in charge of the operation and maintenance of the system. The irrigators' association (IA) is the farmers' management unit, which consists of multiple turnout service areas (TSAs) (Fig. 4). The Bayongan system was started with 11 IAs and 150 TSAs. The TSA involves a group of farmers who share a turnout gate. The group is called TSAG (*chag*). Average size is 20 farmers; range from 70 to 4. The IA and TSAG are formed on the basis of hydrological water boundaries, which may or may not be the same as the boundaries of traditional communities. Hydrology-based communities are overlaid on the traditional communities. The IAs were downsized in May 2010 from a large 11 IAs to 21 smaller ones. One feature of the new IAs is the reestablishment of the IA on the basis of the service area of each lateral. The members of the new IA consist mostly of farmers in the same lateral. In this regard, the new IAs overlap more closely with water-sharing communities. In principle, the system is managed under an agreement between NIA and the IAs, and decisions are conveyed to the TSAs under each IA.

NIA's responsibilities include the maintenance of dams, main canals, and laterals; scheduling of dam operation, and control of water discharge at the dam, main canals, and laterals. In some exceptional cases, NIA also controls the water gate of some TSAs when they think that the TSAs do not follow the irrigation schedule. In principle, the TSAs are in charge of the spindle gate and the construction and maintenance of farm ditches.

Another important task of NIA is the collection of irrigation service fee (ISF). Under the current law, an individual farmer has to pay an ISF equivalent to 150 kg of paddy per hectare per season to NIA. This amount is equivalent to about PhP2,500–3,000 (at the market price of paddy at PhP14–20 per kg.)—this is about 5% of gross revenue when the yield is 3 t/ha. The national average of ISF collection was 66 % in 2009 and 67 % in 2010. The collection rate in Boyongan was 79 % in 2009, 2nd season, 66 % in 2010 1st season, and 42 % in 2010, 2nd season.[4]

2.4. Irrigation schedule

NIA changed the irrigation schedule several times during our survey period that covered five cropping seasons. We have labeled them Season 0 to Season 4. The schedule and the features are summarized in Table 4. Under NIA's scheme, one cropping season is divided into several irrigation intervals; NIA then determines how many days water is released in what order between the up and down streams.

When the system started operating in 2008, an irrigation interval is made up of 7 days for the first 6 weeks and 10 days for the succeeding 80 days, a total of 14 irrigation intervals for one cropping season. Each irrigation interval had 6 irrigation days 24 hours a day, the first 3 days for the upstream laterals and the next 3 days for the downstream laterals (thus, there is 1 no-irrigation day in each of first 6 intervals and 4 no-irrigation days afterward). This schedule was used in the first two seasons in our survey period. Since water was discharged even at night, total supply of water was plenty. During these two seasons, many unwanted events happened; nighttime monitoring was difficult and water stealing was rampant during the night, which resulted in conflicts among the farmers.

Accordingly, NIA decided to release the water only during daytime. At the same time, the rotation between upstream and downstream was abandoned. One irrigation interval is made up of 2 weeks with 6 days of simultaneous irrigation of the entire system (thus, there is no irrigation for 8 days in one interval). One season consists of 10 intervals. This schedule was used only in Season 2. Under this simultaneous irrigation schedule, many downstream laterals suffered serious water shortage. Even the farmers in the upstream laterals had dry fields after 8 days of terminating water release at each interval. Total water supply under this schedule was smallest of all seasons. Note, however, that a severe drought occurred in Season 2. This, in addition to the rotation schedule of the season, could have caused the frequent drying of the rice fields.

[4] The ISF correction for 2011 1st season is not due yet and the rate is 23% as of 2011 November.

In Season 3, to address the problem of the downstream water shortage as well as the long termination period, rotation from downstream to upstream was introduced, under which each segment can receive water for 6 days in 2 weeks. Although the termination of water was still 8 days for each segment, the water shortage problem diminished as each segment received water exclusively for 6 days. Water was released only during daytime. Total water supply was much higher than that during the previous season.

In Season 4, a minor change was made to address the water shortage problem during transplanting. In the new schedule, water was released for 9 days during the first three intervals with the same rotation pattern. For this, total water supply was slightly higher than that of Season 3.

2.5. Rainfall

Based on the country's meteorological classification, Bohol has climate type IV: even rainfall distribution throughout a year. In the project area, there was comparatively little rainfall from February to May and much rainfall from June to January. The average annual rainfall for the last 50 years is 2,042 mm; the range was from 1,246 mm to 3,145 mm.

Figure 5 shows actual and effective rainfall of three metrological stations in the study area, by irrigation season. Irrigation season is defined as the period from dam opening day to closing day. Data from some stations are missing in some seasons because of the nonexistence or the malfunctioning of the recording equipment. By interpreting these figures, together with total water supply from Bayongan dam, we came up with the water availability profile during the survey seasons.

- Season 0: low rainfall and plenty of dam water supply
- Season 1: normal rainfall and plenty of dam water supply
- Season 2: low rainfall and limited dam water supply
- Season 3: normal rainfall and moderate dam water supply
- Season 4: abnormally high rainfall and moderate dam water supply

In short, we may classify Seasons 2 and 4 as water stress seasons, with the former as the season of little access and the latter as the season of too much water. The other seasons were not so problematic. These conditions affected the amount of water demanded by each TSA. Needless to say, rice cultivation in the rainfed area was directly and fatefully affected by rainfall.

2.6. Agriculture before and after irrigation project

A feasibility study in 1985 (JICA, 1985) estimated the arable land in the project area at 7,100 ha, of which 1,780 ha (25%) is classified as paddy field, 1,900 ha (27 %) as upland field, and 3,420 ha (48%) as grassland. Table 5 shows the cropping pattern and productivity in the area, and Figure 6 shows the cropping calendar taken from the feasibility study. Even before the project, rice is the dominant crop and is cultivated twice a year, when rainfall conditions allow. Cropping intensity is 165 %. Rice is extensively cultivated using the traditional method with minimum application of farm inputs, resulting in a yield of 1.32 t/ha (about 65 % of the national average) (JICA, 1985). The major upland crops are cassava and sweet potato, which have an almost equal share in the 1,000 ha upland fields. They are cultivated on hilly land without any fertilizer and weeding operation (JICA, 1985). The resulting yields of these cops are as low as 50% of the national average. Grassland includes the coconut or mango tree area. The study area before the irrigation project may be described as a traditional rainfed rice economy with significant existence of root and tree crops. The study areas adjacent to the project site are still under the rainfed ecology and have retained the same agricultural characteristics.

After the irrigation project, rice became more dominant. Some upland areas have been converted into rice fields. For this, farmers entered into a contract with NIA and shouldered the cost of 90,000 pesos per ha for land leveling. Repayment must be made within 20 seasons (i.e., 10 years) at the rate of 4,500 pesos per season per hectare without interest. The remaining upland areas are still used for the traditional cassava or sweet potato cultivation.

2.7. Social structure

Bohol is located in the Central Visayas region where *Cebuano* is the common spoken language. The *Cebuano* ethnic group used to be the largest group in the country and recently has become the second largest group after *Tagalog*; the same trend was noted with the *Cebuano* language. Regardless of its significant presence in the country and compared with the number of references on the*Tagalogs* e.g., Hollnsteiner (1967), Hollnsteiner (1972), Kaut (1965), and Lynch, (1967)those pertaining to *Cebuano* society are limited. An intensive exploration of the social structure of the *Cebuanos* with a particular focus on our study area is beyond the scope of this report. In this subsection, we list a few important keywords and their explanations to assist us in understanding the impact on the value system of the community under study.

- Bilineal society — Kinships in the Philippines can be extended to both father‘s and mother‘s sides. There is no clear rule that determines which kinships are included and which are excluded. Kaut (1965) argues that they are determined by contingent factors. This is considered

		the base of a loosely structured village where boundaries are individually different.
•	Roman Catholic	The dominant religion in the country and also in the study site. A godmother/godfather is expected to be not only spiritual but also economic/social supporter some times. Since the same indeterminacy applies to ritual kinship relationships (Tamaki, 1982), the expected roles also depend on contingent factors.
•	Patron-client	A relationship in which a patron is expected to give a means of earning or help and protection, while a client is expected to give back labor or personal favors. Examples in rural life may include the relationship between a landlord and his/her tenant and a politician and his/her supporter.
•	*Utang na kabubut-on (utang na loob)*	Sense of indebtedness in receiving treatments. Lack of this sense is considered shameless. The receiver does not have to return favors immediately but at least is expected to keep the feeling of indebtedness.
•	*Makikiusa (pakikisama)*	Smooth interpersonal relationship by being united with the group.

Local terms are in Cebuano, Tagalog in parentheses.

Social structure and behavioral rules have been developed through the history of events and interactions under a specific ecological condition. Irrigation can be an epoch-making change in an agroecological condition, which will dramatically change the farmers‘ production mode. It changes not only productivity and risk of production but also the way of production, particularly water management, as it increases the demand for collective management of the irrigation system with other members. We will examine how these changes affect the farmers‘ traditional value system and behavioral rules.

2.8. Local government systems and village structure

The most important local government unit in a farmer‘s daily life is the *barangay*, which means ‗village‘ in the local term. It is the lowest level of local governance hierarchy after municipality. The barangay is important because it has its roots in a natural village and the informal customs and norms prevailing there still govern people‘s behavior. Because of the bilineal and contingent personal relationships as explained in the previous section, the boundaries of a community are individually different, making the barangay as a loosely structured unit, although the barangay itself has an official administrative boundary. The concept of ―loosely structured" village was first presented in Embree‘s study on Thai society and applied to Southeast Asian societies by a number of scholars.

Based on these studies, Nakane (1987) characterized a rural society in the Philippines as a community that is based on unclear, unstable, and individually different personal relationships, and therefore, does not have a clear boundary as one unit, spreading widely beyond administrative borders. Under such a circumstance, villagers do not expect much administrative service from the barangay. The most important task expected by the villagers of the barangay is the maintenance of peace and order. The barangay police (*barangay pulis*) and court (*lupon barangay*) are the organizational units for this purpose.

Nevertheless, the administrative importance of barangays slightly increased after the passage of Local Government Code of 1991 and the Local Government Autonomy (Republic Act No. 7160) in December 1992 under President Fidel Ramos. With this code, the barangay became an official administrative unit. With the latter act, the fiscal base of the barangay is assured by the transfer of the internal revenue allotment (IRA) from the central government as well as by the transfer of part of the municipal tax from the municipal office. Before the act, the barangay had no financial source, unless villagers voluntarily agree to contribute. IRA is used not only to pay the salaries of barangay officials but also to promote public work projects. Nevertheless, the salary rate is not sufficient to make village officials take these positions full time (about 4,000 to 6,000 pesos/month) and the major public works still come from the municipal or national level. In this regard, we may say that the barangay‘s role as the lowest level of administrative service unit of the state is still weak, while people still find its importance in the maintenance of peace and order through strong personal interaction based on informal customs and norms as well as through legal coercion based on formalities.

In principle, one barangay is further divided into seven subunits called *purok,* regardless of the size of the barangay. The purok system is introduced in order to facilitate information distribution and mobilization of local residents. The borders of a purok is determined on the basis of equal geographic size of each purok. Therefore, although many puroks consist of people with close kinship due to geographical proximity, it has no traditional background in purok per se. Hence, its function seldom goes beyond information dissemination as originally planned.

The barangays and puroks in our study site share these features basically. A notable feature of our study site, which may be important in the analysis of personal relationships, is that the places of residence are relatively scattered over a wide geographical area, although we can still find a center of a barangay where residences and small businesses are concentrated. In this regard, the nature of ―loosely structured" village may be stronger in our study site than those having a core residential area.

It is important to recognize that IAs and TSAs, which are organized on the basis of hydrological boundary, do not necessary overlap with traditional barangays. In fact, most of the TSAs consist of members of several barangays, with one dominant barangay in many cases. Hence, on the one hand, one may claim that the community mechanism in TSA may not easily emerge or, even if it emerges, it may not be a mere duplication of the barangay community mechanism. On the other hand, because of the loose structure of the barangay, belonging to different barangays may not hinder the construction of a new TSA community on the basis of existing barangay communities. Since an understanding of the TSA's community mechanism is important for water management, this empirical issue will be explored later in this report.

3. Methodology

3.1. Approach

To take care of the issues pointed out in the introduction, we have developed an approach with four distinct features. We may describe our approach as a multifaceted impact assessment with a counterfactual case selected mainly on the basis of hydrological aspects.

(1) Selection of counterfactual case by a method suitable for the evaluation of a single irrigation project

In this study, we selected the rainfed areas that have passed a few selection criteria, which we will introduce later, as a counterfactual case of the irrigation project. Popular statistical methods for impact assessment are not perfectly suitable for our case for reasons explained below.

One common statistical method is a difference-in-differences method (DID, hereafter). Figure 7 (i) shows the concept of this approach, which indicates the changes of impact index (on Y axes) in treated and untreated cases over time (on X axes). In this figure, the impact is indicated by C as B minus A. Since A is the change occurring over all, the magnitude measured as B minus A can be solely attributed to the change caused by the treatment. A critical point is that an overall change (A) occurs in the same magnitude in both treated and untreated, under the assumption of time-invariant unobserved heterogeneity. Hence, this can be a powerful tool if we can use the data before and after the project both in the treated and untreated areas and also if we can safely assume the time-invariant nature of the unobserved heterogeneity. Unfortunately, however, for this study, we do not have these baseline data. This approach cannot be an option.

A method getting popular for impact assessment is regression discontinuity. Conceptually, this method compares the mean difference just below the cut-off point and just above the cut-off point, assuming that the eligibility of the treatment is determined by the threshold cut-off point. Considering the boundary of the irrigation service area as the cut-off point, we may apply this approach for our impact assessment. However, it is better to note that the impact captured by this method is the one realized at the margins of the irrigation boundary, which may not be equal to the impact of the irrigation project as a whole. This concern seems to be serious, particularly in the impact assessment of the irrigation project because water could become scarcer and the benefit could be smaller as it moves toward the irrigation boundary. In this regard, we refrain from using this approach this time and keep it for our future research for a more detailed analysis as well as for a robustness check.

The other popular statistical treatments are propensity score matching (PSM) and instrumental variable (IV) methods. Both rely on the regression analysis of the determinants of the treatment (in our context, access to irrigation). This is a statistical process to identify the observations which were supposed to receive the treatment but actually not (i.e., counterfactual observations in the available sample). These approaches are useful when there exist variations in treated and untreated, so that the probability of treatment can be estimated by regression analysis. In the context of irrigation projects, if we have data on so many observations with and without irrigation projects, à la Duflo and Pande (2007), we may statistically identify counterfactual observations. However, our study is an impact assessment of a single project. Once the irrigation project is implemented, all the farmers in the service area receive irrigation or become ‗treated‘. We will not use these approaches in our study.

The approach we are going to use relies more on the selection of counterfactual cases on the basis of reasonable criteria, rather than regression analysis for the identification of counterfactual cases. Conceptually, a counterfactual observation corresponds to a rainfed farmer who has background characteristics ―similar” to those of an irrigated farmer. In the context of the irrigation project, the similarity can be judged on the bases of hydrology (or feasibility of the irrigation project), agronomy (potential of irrigated agriculture), and socioeconomic factors (or ability to use irrigation potential). In our approach, by carefully selecting the farmers in adjacent rainfed areas who satisfy the similarity criteria, we construct counterfactual observations. This approach may be regarded as a special case of DID or matching without relying on the propensity score. In Figure 7 (ii), this approach can be shown as the selection of an untreated group in such a way that the starting point before the project coincides with the starting point of the treated group as close as possible. In this case, the impact can be fairly approximated by the current difference between treated and untreated without a baseline survey. As a kind of DID, this approach still assumes time-invariant unobservable heterogeneity. More details of the selection criteria and results are explained in Section 3.4.

A concern about our approach is the possible existence of an indirect impact of the irrigation project on the adjacent rainfed area. Through the adoption of labor-intensive modern technology in the irrigated area, the project may increase the labor demand in the adjacent rainfed area. Besides, migration from a rainfed to an irrigated area to seek higher income could make rainfed samples different from what they were in the beginning. However, during our field data collection, we have confirmed by interviews with rainfed farmers that there are a few cases when they started working for irrigated farmers after the project and that there is no instance that someone moved to an irrigated area.[5] Another example is that, through the price reduction in output market, an increase in rice production in the irrigated area could contribute to poverty alleviation in the rainfed area. We have also confirmed by interviews with rice retailers and rice millers that production increase has not yet been large enough to generate such an effect in our study area.[6] In this regard, we judge that this study will rely on the approach we explained above because the indirect impacts through forward and backward linkages did not seriously affect the rainfed areas, at least during our survey period.

(2) Comprehensive impact indicators

Irrigation changes many aspects of a farmer‘s life dramatically. Directly, it changes the productivity of newly irrigated parcels and the income from those parcels. Accordingly, farmers would adjust resource allocation to other farming and non-farming activities, resulting in a change in income, also from the other activities. The effect would not be limited within economic activities, particularly in the case of an irrigation project. Through collective management of the irrigation system with others, the farmers‘ social activities could be affected. Then, as a result of the changes in economic and social activities, the irrigated farmers‘ value system and behavioral rules may not be what they used to be when they were rainfed farmers. This study tries to capture as many of these changes as possible.

Indicators related to economic activities and outcomes included input, output, and income of an irrigated parcel, and total agricultural and non-agricultural income per capita. The changes in inputs would show the process of agricultural modernization. We also show the changes in asset position as more stable and long-term impact indicators. Indicators related to social activities include participation in collective action and the existence of bilateral informal transactions within and beyond a community.

The values and behavioral rules were measured by artefactual field experiments, which consist of behavioral games designed to elicit the participant‘s attitude through real money transactions in the games. Examples include a dictator game, a trust game, a public goods game, and a risk game. We conducted the artefactual field experiment for one-third of our samples in the irrigated and rainfed areas. The details of the game structure and the meaning of the game results will be explained in Section 4.6 when we analyze these indicators.

[5] All the land transactions observed during the survey period were within irrigated farmers or within rainfed farmers.

[6] The rice market of the study area is fairly integrated with large cities not only in Bohol but also in Cebu and Leyte.

(3) Long survey period for the assessment of seasonality

The third feature of our approach is our data collection for at least four consecutive seasons so that we can capture differential impacts over seasons. This approach is particularly important in our case because of the role of the irrigation system as an insurance against rainfall. The potential of irrigation is fully realized in a drought season, while it may not be so discernible in a good-rainfall season. By capturing differential impacts under different rainfall patterns, we could estimate the impact fairly. Our data set is in fact appropriate for this purpose because the study site had experienced normal, drought, and flood years during the survey period (see Section 2.5).

(4) Disaggregation of impacts

Most impact assessment studies focus only on the average impact of a project in comparison with the counterfactual case. However, as part of project outcome, the equity issue within the project must be properly addressed. Taking advantage of the availability of household-level data, we attempted to assess differential impacts, by different beneficiary group. Examples included the comparison between upstream and downstream, large landholders and smallholders, and female-headed households and male-headed households. However, statistical difficulties arose because the grouping was barely random. Also, the identification of the counterfactual case is extremely difficult. For example, in a gravity system, it was difficult to find farmers who are supposedly upstream but turn out to be located downstream. Therefore, in this report, we will take a normative approach, in which the criterion of equity is whether all farmers in the system access water equally.

In the context of the irrigation project, the difference in water access between upstream and downstream farmers is the most crucial issue, given the innate hydrological advantage in the former group. On the other hand, the overuse of upstream farmers may not increase water stress in the downstream farmers if the overused water moistens the downstream ground by percolation through the soil. This means that inequitable water distribution does not necessarily means inequitable water access. Hence, this issue must be empirically examined. Equity between large and small farmers is another long-debated agrarian issue as the larger ones may have the power in controlling water distribution in their favor. Other possible sources of inequality include asset position, tenancy, and gender. We will also examine these issues empirically.

As a supplement to this analysis, we show ex-post equity between the groups of categories mentioned. If an impact indicator is not statistically different between the groups, we take it as supportive evidence, which implies that the project did not worsen the equity of the two groups. Note, however, that even when a difference exists, it does not necessarily mean that the impact was against the low group because the low group was even in a much lower position before the project. This means that this supplementary analyses show equity in resulting outcomes rather than equity in changes caused by the project.

3.2. Data collection strategies

3.2.1. Schedule, questionnaire design, and data collection

Table 6 shows the schedule of the survey. In this study, we collected household- and TSA-level data (the latter were collected only from the irrigated area). This study was originally started by IRRI and JIRCAS in November 2008. It focused only on irrigation management and the resources available for the research were limited. Hence, the original study covered only upstream laterals in the irrigation scheme. Upon getting financial support from JICA, an impact evaluation component was added and, for this purpose, the study site was expanded to include the downstream laterals and the rainfed areas. Data collection was conducted every season until the 2010 November–2011 April season, meaning five seasons in upstream and four seasons in downstream and rainfed. After the last season, we conducted field experiments for a subsample of the farmers. One important statistical feature of our data collection strategy is interviewing the same households and the same TSAs over the seasons. Hence, our data set has five-round seasonal panel data in the upstream and four-round seasonal panel data in the downstream and rainfed areas.

We have developed three data collection modules: (1) a household-level questionnaire, (2) a TSA-level questionnaire, and (3) a TSA-level water volume record sheet. The household-level questionnaire solicited the following information: (a) household demography, (b) landholdings, (c) inputs and outputs of rice and other major crops, (d) activities related to irrigation, (e) non-farming activities, (f) credit access and use, (g) livestock holdings and animal products, (h) household expenditure, (i) household assets, and (j) social capital. Since social capital does not change shortly, we asked the questions only in the first and last rounds of our survey. An enumerator visited a sample household and obtains the information through a face-to-face interview.

TSA-level questionnaire was developed to capture the characteristics and performance of theTSA, which covered the following: (a) size and composition of membership, (b) land and infrastructure characteristics, (c) irrigation management, (d) group-level social network, (e) homogeneity of the group, (f) cognitive social capital, and (g) communal collective activities other than irrigation management. A full set of questions was asked only during the first and the last seasons; otherwise, only irrigation management of the target season (questions in (c)) is ascertained. This module was not applicable to rainfed farmers. The data were collected by interviewing members of the TSA committee and other available members.

The last module is for the measurement of water volume used by the TSA. Record keepers visit a turnout twice every day during the irrigation period and record the water level (height) of the attached gauge on the turnout. The volume is calibrated from the recorded water levels.

The survey modules of the first and last seasons as well as the documents on water volume measurement are available as supplementary documents.

3.2.2. Sampling strategy

Of the 150 TSAs under the Bayongan system, our survey covered only 147. Because of the merger and abolition of some TSAs, sample size went down to 139 in the last season. Three TSAs were dropped since they did not function well and the service area of these TSAs remained rainfed. At each TSA, we have sampled one household each from upstream, middle stream, and downstream within a TSA. However, some TSAs with a few members and a small service area were divided only into upstream and downstream. Hence, there were only two samples per TSA, bringing the sample to 418 irrigable households in 147 TSAs. Table 7 shows the membership and sample size of the sample TSAs.

For impact assessment, we selected adjacent rainfed villages that have a similar background to those in the irrigated area. We have chosen the adjacent villages as our target because the agroclimatic conditions of there are similar to those in the irrigated area. We likewise paid attention to the similarity in agrarian status of the farmers. At the time of the sampling, a distinct feature in the irrigated area recognized by the survey team and NIA is the existence of a significant number of land reform beneficiaries, who obtained the farmland property right under the Comprehensive Agrarian Reform Program (CARP). Therefore, as our sampling strategy, we first selected the rainfed villages with land reform beneficiaries, and then randomly sampled our observations, which generated the sample of 429 households in 13 villages. Table 8 shows the sample size, by village. In total, our sample consisted of 847 farmers, some of them dropped out later due to attrition. Figure 8 shows the location of the surveyed parcels (not the residences of our sample) in our study area.

One important issue about sampling must be addressed. Because the sample size at each TSA is basically fixed at three, regardless of the population size of the TSA, the sample from the irrigated area does not correctly represent the composition of the entire farmers in the irrigated area. For example, three sample farmers from a large TSA underrepresent the farmers in that TAS. Meanwhile, we can safely regard the rainfed sample as random sample. Therefore, we control for sampling weight in the irrigated area.[7]

[7] For this purpose, we used the *svy* command in STATA.

3.3. Randomized field experiments

As a subcomponent of this study, we investigated what kind of institutional design and technologies are effective on water savings for efficient and equitable water use among the irrigated farmers. This is not only an important issue by itself but also a crucial point to sustain the impact of the irrigation project. For this purpose, we paid attention to volumetric pricing as a possible new institutional arrangement and to alternate wetting and drying (AWD) technology as a new water-saving technology.

3.3.1. Volumetric pricing

The current pricing system used by NIA is area-based pricing. As explained in Section 2.3, an individual farmer has to pay an irrigation service fee (ISF) equivalent to 150 kg of paddy *per hectare* per season. Under this pricing system, farmers do not have an incentive to save irrigation water as the marginal cost is zero. This is one of the reasons for the overuse of the upstream farmers. Volumetric pricing is considered a solution to this problem, assuming that the price elasticity of irrigation water is not low. Indeed, if upstream farmers are actually overusing beyond the required amount, elasticity must be high instead.

However, in a gravity irrigation system, measuring water volume precisely at an individual rice parcel is practically impossible. Meanwhile, it is still tractable at the TSA level as long as the turnout structure is reliable and stable. In the Bohol system, unlike in other typical irrigation systems in the country, canals and laterals are all lined and each TSA has a concrete turnout with a steel spindle gate. The spindle gate makes water control easier, although water control is still possible by using obstacles such as sandbags, wood plates, and even gavages. Hence, in the Bohol system, farmers can adjust their demand according to their need under volumetric pricing. Besides, the concrete structure of the turnout with a water gauge attached makes measurement of water volume at the TSA level possible. Taking into account these practical issues, we have decided to introduce a *group-level* volumetric pricing in the study site. Hence, the amount of water savings depends not only on the individual farmers' price elasticity but also on the success of collective action for water savings among the TSA group members.

The volumetric pricing system we introduced for this survey is some kind of a bonus system. We merged this system with the current area-based system rather than change the pricing schemes and price levels. We have decided to do so partly because NIA has to do its business as usual. We provided only a bonus but not a penalty because we did not want the participants to be worse off after the experiment. In our system, we first computed the water volume required to continuously flood the rice fields for each TSA. The required volume becomes smaller when farmers get rainfall. Controlling for contribution by rainfall, we set a threshold level of the required volume. Then, if a TSA saves a certain percentage of water from the threshold, we pay back the same percentage of ISF (total of TSA) to the TSA, not to the individuals. We set the maximum return rate at 40%. For example, if a TSA saves 15% of the water, 15% of the ISF is returned to the TSA. Even if a TSA saves more than 40%, the return rate remains at 40%. To make this arrangement effective, we entered into a contract with the TSA every season. (See supplementary documents B for the contract form.)

To assess impact, we randomly assigned the volumetric system to half of the TSAs after Season 0. We can use Season 0 as the baseline. (See Figure 9 for the timing of the intervention.) In summary, this experiment investigated whether the volumetric bonus system at the TSA level contributed to water savings by collective water savings among the TSA members.

3.3.2. AWD technology

AWD is an irrigation practice to reduce irrigation water from 15 to 35% without any yield penalty by letting the rice field dry at the stage when the crop is not so sensitive to water stress. Figure 10 is a schematic diagram of the irrigation schedule under AWD with rice variety RC-18 (it has a 120-day growth period). A training course was conducted to show farmers how to save water by practicing AWD; it usually took half a day for lecture and half a day for field practice.

In our experimental design, we provided training to half of the volumetric TSAs and to half of the control TSAs, so that we had four cases of with and without combinations of two kinds of randomized interventions. Training was given between Seasons 2 and 3 (Fig. 9).

3.3.3. Hypothesis and implementation

The training on AWD provided knowledge about water savings, and volumetric pricing provide an incentive to save water. We hypothesized that water savings are fully achieved when farmers have an incentive to do so and if they know how to do it. Since water savings require changes in collective water management, this may require institutional changes in the TSA i.e., changes in the rules and organization of the TSA for more efficient water use. Such an institutional change in the TSA would require time as changes are made piece by piece, on a trial-and-error basis. Therefore, the effect may be shown as in Figure 11 under an assumption of constant rainfall, just for simplicity. The case of volumetric pricing without AWD knowledge may be effective but not as strong as the case with AWD knowledge. Although some farmers may still reduce water use once they learn about AWD practice without volumetric incentive, we did not expect many to do so if there is no tangible benefit under area-based pricing. Lastly, if there were neither incentive nor knowledge, we would not observe any water savings.

When we designed these interventions, no other interventions from other parties were expected. However, the Department of Agriculture (DA) provided AWD training during our survey period to a group of farmers selected using the DA's own criteria. Because of this, we cannot regard the AWD training as a random intervention any more. Besides, we have realized later that some farmers belonged to multiple TSAs because they have parcels in both TSAs. Therefore, we cannot safely claim that AWD knowledge is random at the TSA level. Therefore, unfortunately, in this study, we refrained from analyzing the impact of AWD training; we focused on the impact assessment of volumetric pricing only.

3.4. Selection of rainfed area as a counterfactual case

Although we have paid due attention to similarities in terms of agroclimatic conditions and the existence of land reform beneficiaries when we selected the rainfed villages, it did not automatically assure that our sample is an appropriate counterfactual case. A more careful selection is needed on the bases of criteria set by related disciplines. This subsection explains the method and the results of counterfactual case selection.

In our analysis, we introduced criteria set by three disciplines which are closely related to the potential impact of the irrigation project: hydrology, agronomy, and socioeconomics. First, the rainfed area must have similar hydrological conditions in terms of making the irrigation project feasible. In other words, as a counterfactual case, the selected rainfed area must be an area that could potentially be irrigated but actually was not. There were some areas originally included in the 1985 feasibility study but were not in the actual service area, with hydrological conditions similar to those of the actual service area. We may be able to consider the rainfed parcels in that part as candidates of counterfactual observations. In Figure 12, the shadowed area indicates the irrigable area identified by the feasibility study. This means that the rainfed parcels (red dots) under the shadow are potentially irrigable plots. In addition, NIA conducted an original feasibility study in the 2000s to investigate the feasibility of expanding the current irrigation system, identified that the areas in Humayhumay and Pangpang villages (northeast corner in Figure 12) can be irrigated using runoff of the current system and water from natural creeks. In our study, we considered the rainfed farmers included in these two feasibility studies as the primary candidates of our counterfactual case and those included in JICA's original feasibility study only as secondary candidates. Of 429 rainfed sample farmers, the first candidate group consisted of 211 and the second one consisted of 118, while 218 rainfed farmers were completely outside of either feasibility study.

Second, the similarity in agronomic condition is important as it determines the potential of irrigated agriculture (for example, potential yield under irrigation). Since we have selected a rainfed area from an adjacent area, agroclimatic conditions are supposedly similar. Of the available documents, JICA's feasibility study in 1985 showed two past studies and their own study on the soil type of the project area. The first study in 1972 (*Soil map of the Philippines-around Bohol Province*) classified both the irrigated area and the area under the first candidate group into one soil type called Ultisols (Fig. 13). This applies to our second candidate group as the first group is inclusive of the second one. The second study pointed to the classification issued by the Bureau of Soils in 1947; most of the irrigated area and the first candidate group's area have Ubay sandy loam with very minor presence of Ubay clay (Fig. 14). The study conducted by JICA also showed the majority of the irrigated area and the first candidates' area as belonging to category Ubay Loam type 2, while there were patches of Ubay sandy loam (Fig. 15). In this regard, we may claim that the irrigated area shares similar characteristics with our candidate groups, thereby satisfying the agronomic criterion.

Third, similarities in socioeconomic characteristics are equally important as they influence the potential of irrigation project through the ability to use irrigation water. Nevertheless, comparing similarities in this category is not easy because we do not have baseline data and because some aspects of ability are unobservable. However, one advantage of our study is that we started data collection shortly after the start of the operation. We may still be able to compare variables that tend not to change dramatically in the short run.

Table 9, Panel A presents the results of the mean comparison of selected household characteristics in the 2009 first season between irrigated farmers (labeled (1) on the top of the table) and different groups of rainfed farmers (labeled (2) to (5))the groups consisted of (2) rainfed farmers included in the two feasibility studies (first candidate), (3) those included in the original feasibility study alone (second candidate), (4) those outside of either feasibility study, and (5) all rainfed farmers. As comparable stock variables, we showed household size, female member percentage, schooling years of household head, total landholding size (sum of irrigated and rainfed), livestock values, non-agricultural asset values, and proportion of land reform beneficiaries. Sampling weights in the irrigated area are controlled. The results showed that the percentage of female members was significantly higher in either case of our candidate groups ((2) and (3)). Note, however, that the difference was merely about 3 percentage points in the case of our first candidates. Among the rainfed groups, we judged that case (2) rainfed farmers in the two feasibility studies was the most suitable as the counterfactual case because a statistically significant difference is found only in the female member proportion.

In Panel B of the same table, we examined whether the mean yield in the rainfed area in the 2009 first season was statistically different from the yield of 1,320 kg/ha, which was taken from the feasibility study and thus can be considered typical yield of an irrigated area *before* the start of the irrigation operation (Table 5). The results showed no statistical difference in any rainfed groups, except for case (3), which we may take as an additional support for our choice of case (2).

Taken all together, we have decided to use the sample of 211 rainfed farmers included in the two feasibility studies as the counterfactual ones. Hereafter, we use this group of rainfed farmers for impact assessment when we compare impact indicators between irrigated and rainfed. As a reference, in the appendix figures, we will show the indicators of the rainfed farmers outside of the feasibility study, which shows the situation of an *un-irrigable* area in comparison with an irrigated or irrigable rainfed.

4. Impact Evaluation

For the assessment of the impact of irrigation, sub-section 4.1 examines the mean differences between sample irrigated rice farmers and the counterfactual rainfed rice farmers. This comparison was made by season in order to investigate the dynamics of irrigation impact. To investigate differential impacts within the irrigation scheme, sub-sections 4.2 to 4.5 statistically compared the selected impact indicators between the groups classified on our interest. Subsection 4.6 shows the impact of volumetric pricing on TSA-level water-saving behavior over the survey periods. On interpreting the results over the survey period, we should note that the 2nd period was a severe drought season and the 4th period was a flood season. Lastly, using the results of the field game experiments, we compared the social values between the rainfed and irrigated groups, where the irrigated groups were further divided into volumetric pricing and area-based pricing groups.

4.1. Comparison between irrigated and rainfed

For a detailed understanding of the impact of irrigation on farming and livelihood, we have selected several impact indicators. Table 10 shows the variable name, the definition, and the type of impact measured by the variable. Figures 16 to 30 show means, standard errors, and *t*-test results of selected indicators between the irrigated area and the rainfed area inside of the FS over the survey periods. Figures in the appendix show the same statistics, including the rainfed area outside of the FS.

The findings are summarized as follows.

- Paddy yield (measured in dry paddy equivalent weight) was always higher in the irrigated area (around 2.5 t/ha per season) in comparison with the rainfed area yield (around 1.3 t/ha per season). However, even in the irrigated area, they could not completely evade the negative impact of the drought (season 2) and the flood (season 4) (Fig. 16).[8]

[8] Paddy after drying of fresh harvest (wet paddy) is called dry paddy, which is about 14−16% lighter than wet paddy.

- Modernization in terms of increase in chemical fertilizer use (Fig. 17) has been proceeding in the irrigated area. This reflects the complementary relationship with fertilizer and water. Nevertheless, the amount of nitrogen applied (50−60 kg/ha) was still lower than what was recommended (90 kg/ha), even in the irrigated area. There is room for further yield increase with better nutrient management. Note that land leveling was implemented as part of the irrigation project (at farmers‘ expense). This also contributed to the yield increase because patchy dry soil in a paddy field causes a delay in crop growth and accelerates weed growth on dry spots.
- Modernization in terms of adoption of a newer modern variety (hybrid rice in Figure 18) has been emerging when weather condition is normal (seasons 0, 1, and 3). On the other hand, hybrid rice was adopted to some extent in the rainfed area when it was introduced; however, they turned back to inbred modern varieties. This is understandable as hybrid rice can achieve the expected yield under strict management of nutrient and water.
- Accordingly, we observed higher revenue (Fig. 19) and higher cost (Fig. 20) in the irrigated area. Since the increase in revenue was greater than that of cost, we observed higher rice income per ha (Fig. 21) in the irrigated area than in the rainfed area. We may claim that the rice farming system in the irrigated area is moving toward a high-input-high-output system.
- Note that the rainfed rice farmers sharply reduced their production cost in the drought year (Season 2 in Figure 20), while the irrigated rice farmers barely changed their inputs over the seasons. This indicates the rainfed farmers‘ ‗self-defense‘ management strategy against drought shock.
- Yield variation was much wider in the rainfed area, particularly in the drought year, indicating the area‘s higher and heterogeneous susceptibility to drought shock (Fig. 22). Meanwhile, flooding did not have such an effect.
- Putting the survey parcel rice income and the income of other parcels (Fig. 23) together, agricultural income per capita (Fig. 24) showed that flood, rather than drought, was a more serious problem in the irrigated area under this system.
- Given the lower agricultural productivity in the rainfed area, farmers relied more on non-agricultural income for their livelihood (Fig. 25). Many of non-agricultural opportunities in rainfed area are casual work. Total amount was large but earnings from each activity were very small. We infer that non-agricultural income used to be important also in the irrigated area, but, after the start of irrigation, farmers used more of their time to stable agriculture.[9]

[9] Since we do not have baseline data, we cannot deny the possibility that non-agricultural income of the irrigated area was low, even before irrigation. However, given the fact that the labor input for rice is 1.5 times higher in the irrigated area than in rainfed area, on average, we suppose that our statement is not so outrageous.

- Summing all income sources together, Figure 26 shows the dynamics of total household income per capita over the survey period. The income of the irrigated area grew faster than that of the rainfed area until the 3rd period. Although the second period was a drought year, the income of irrigated rice farmers increased, while that of rainfed rice farmers decreased slightly. The negative shock from the flood was dramatically large in the irrigated area and the income went down to the level similar to that in the rainfed area.
- Stability of income is another important aspect of livelihood. To examine this point, we computed the coefficient of variation (CV) for each individual household over the four seasons. Hence, this is a measure of individual-level seasonal income fluctuation. The result showed higher fluctuation in the rainfed area (Appendix Fig. A1).
- To look at the impact on the household‘s long-term welfare, we compared the asset position in the two areas. It is natural that agricultural asset value has been higher in the irrigated area as agriculture is the dominant income source there (Fig. 27). The asset more directly related to welfare is the value of non-agricultural assets, which included TVs, motorcycles, and mobile phones. Figure 28 shows that value of such assets has been increasing in the irrigated area, while it has been stagnant in the rainfed area. Accordingly, Figure 29 shows a similar pattern on total asset value.
- The change in livestock values in Figure 30 showed a sharp decline in the irrigated area, reflecting the substitution of machines for draft animals.

4.2. Comparison between upstream and downstream in the upper portion or lower portion of the main canal

This subsection examines the differential water access along the main canal. As explained in the irrigation schedule (subsection 2.4), the main canal was divided into two portions (upper and lower), and irrigation water was rotated exclusively between them (except in Season 2). In this regard, each portion received the designated amount of water. A distribution issue could arise between upstream and downstream in each portion. Therefore, we compared water access between the upstream of the upper or lower portions and the downstream of the upper or lower portions.

Accessibility to water is measured by the experience of water stress. To capture that, we introduced a new variable, *dryf_4060,* defined as the frequency of dry soil condition during the period in the days after transplanting (DAT) from 40 to 60 days. For the common rice varieties in Bohol, this period corresponds to the flowering stage, at which an experience of water stress critically penalizes yield; thus, continuous flooding is recommended even under AWD practice. [10] For example, in the case of the most common

[10] Theoretically, alternate wetting and drying can be practiced even at this crop growth stage without any yield penalty if the irrigation pattern strictly follows the AWD instructions. However, it is practically

variety (RC18), this period corresponds to 40−50 DAT (see Figure 10). For another common variety, RC152, the corresponding period 50−60 DAT. Hence, we set 40–60 DAT as the critical period. In addition to flowering stage, continuous flooding is also recommended at the vegetative stage (0–20 DAT) for the same reason. Since our data showed little water stress during this stage for any sample farmers, we did not use this as an indicator to capture differential water stress. As explained in the section about our approach, for the ex-post examination of equity, we will also compare selected impact indicators such as yield, variation of yield within the TSA, rice income per hectare, household income per capita, and total asset value per capita.

Figure 31 shows that, throughout the seasons, there was no statistical difference in water stress between the upstream and the downstream. Even in the drought season (Season 2), *p* value was 23%, although the gap was slightly wider than during the other seasons. Interestingly, in that season, the frequency of water stress was higher in the upstream, albeit not significant. The difference from Season 4 was statistically significant, but the levels were very low. The results shown in Figures 32–36 indicate that, for all the selected impact indicators, no statistically significant difference was found.[11]This implies at least that the project did not worsen the gap between upstream and downstream. These results indicate that the design and capacity of the main canal is appropriate (or at least manageable) to deliver water equally between upstream and downstream of the currently irrigated area.[12] Note also that the maintenance of the main canal and the control of lateral gates along the main canal are NIA's responsibility. As far as equity between upstream and downstream is concerned, NIA has been properly fulfilling its responsibility.

4.3. Comparison between upstream and downstream along the laterals

In comparison with the main canal, contrasting equity results were found along the laterals (secondary canal). Figure 37 shows that the frequency of water stress in the downstream was higher than that in the upstream during the drought season and the difference was highly significant (at *p* value of 1%). Since the laterals are lined completely, seepage loss cannot be the reason for the stronger water stress downstream. Rather, this problem was mainly attributed to a failure in equitable water rotation among the TSAs along the laterals. The rotation among the TSAs along a lateral is the

difficult to do so in farmers' fields. Therefore, a so-called *safe* AWD practice recommends continuous flooding at this stage.

[11] An exception is the case when yield variation in the 3rd season became significantly higher in the upstream than in the downstream.

[12] The actual irrigated area of this project has yet to reach its target. This result could change if the irrigated area is expanded without any additional construction in the future.

responsibility of the IA. Therefore, the strengthening of IAs to implement a stricter water rotation is important. In May 2010, IA reforms were implemented under the initiative of the NIA. In the past, some IAs cover several laterals, making some IAs very big. The reform aimed to downsize the IA in such a way that one IA covers only one lateral. This would enable the IA to manage its lateral properly. The effect of this reform is an important topic for future research. For this purpose, the lessons learned from JICA‘s experience in the rehabilitation of the Bago River Irrigation System in Negros would be useful; the downsizing of the IA on the basis of water boundary significantly reduced water conflicts among the TSAs.

Besides, the repair of infrastructure is an important factor to facilitate strict rotation by the IA as rotation cannot be done effectively when control of water flow is difficult. As we will explain in more detail later, this irrigation system has two kinds of infrastructural problems: malfunctioning turnouts (for example, strong velocity due to a the lower position of the turnouts relative to the laterals), which is the responsibility of NIA, and (2) malfunctioning farm ditches (for example, water washout due to shallowness or sharp curvature of ditches or stagnation due to impounding), which is the responsibility of the TSAs. Our data indicated that about 6% of the TSAs faced the former and 20% had the latter.[13] This means that repair of farm ditches by the TSA is crucial for effective rotation by IAs. In this case, collaboration with NIA is still important because the lack of hydrological knowledge about ditch design and the lack of manpower and budget for ditch excavation and lining are main bottlenecks. A social problem may aggravate the problems in farm ditches. For example, some landowners do not want a farm ditch passing through their field. It is not easy to find a solution to this kind of conflict, but NIA‘s involvement may be important. NIA can make recommendations as an official agent independent of any groups of the farmers. In fact, NIA has already started some activities in line with these recommendations. An example is the validation of farm ditch lining with NIA‘s own budget (a total of 23 km of lining with PhP46 million spent in 2012). This would ensure stricter water rotation.

As to ex-post equity, the downstream portions of the laterals achieved lower yield from seasons 1 to 4 (Fig. 38), higher yield variation in the TSAs in seasons 1 and 2 (Fig. 39), and lower rice income (Fig. 40), though the difference in rice income was weakly significant at 15%. Nevertheless, Figures 41 and 42 show no statistical differences in income and assets between downstream and upstream farmers along the laterals. The major reason for this is the higher non-rice agricultural income of the downstream farmers. Non-agricultural income of the two groups was almost the same. Through diversification within agriculture, downstream farmers in the laterals compensated for their lower rice income.

[13] This classification is made by water engineers who were hired for this evaluation study.

4.4.Comparison within TSAs

We compared rice parcels within a TSA; up, middle, and down portions. Note that the differences among them would be masked if we included the TSAs to which water supply is sufficiently enough to irrigate all parcels in the TSA. Hence, relying on the results of the lateral-level analysis, we limited our sample TSAs to those belonging to the downstream portion of the laterals as they were suffering from water shortage. The results from the entire TSAs are reported in the appendix figures. As expected, the analysis with entire TSAs showed no discernible differences among the three locations within a TSA.

Figure 43 shows that the downstream parcel suffered the highest water stress in the drought season. Further examination by *t*-test showed that the difference was statistically significant at 5% between down and middle or between up and middle. All activities below the turnouts (for example, construction of main farm ditches and arrangement of water rotation within the TSA) must be handled by the TSA Group (TSAG). The strengthening of TSA is needed to ensure equitable water distribution among TSA members.

Results shown in Figures 44–46 generally indicate that outcomes were not equitable. In particular, Figure 46 illustrates the big advantage of being in the upstream portion in the TSA; they achieved much higher rice income per hectare in the drought and flood years. As in previous cases, however, we could not detect any statistical differences in household income and total asset value per capita, presumably because of the middle- and down-parcel farmers' income compensation efforts.

4.5.Comparison by attendance rate of TSA-level management activities

4.5.1. Impact of management activities

While downstream TSAs along the laterals (particularly downstream parcels in those TSAs) were likely to suffer from water stress as shown in the previous subsections, we observed that many TSAs were able to evade the water stress problem by putting their efforts at collectively managing the TSA. Two activities are important for the efficient and equitable water use within a TSA: (1) meetings to set the water rotation schedule of the season and agreement about each member's responsibility and (2) cleaning of farm ditches. To explore the effect of such activities, this subsection compares selected indexes between TSAs with high attendance rates and those with low attendance rates in either activity. The median attendance rate was used to create two groups.

The results in Figures 49–52 indicate an association between poor performance and low attendance rate in meetings. The TSAs with low attendance rate experienced more frequent water stress (during drought season), higher variation in yield within a TSA, lower yield, and lower rice income, although the differences were not highly significant. Similar patterns were observed with respect to cleaning activity (Figs, 53–56). Although a causality issue between attendance and performance remains in our analyses, having meetings and cleaning are preconditions for any TSA. With respect to the meeting for irrigation scheduling, the water delivery schedule of the NIA varied every season, depending on the weather. Hence, farmers had to meet regularly every season. As to cleaning and maintenance, since the main farm ditch is of earth structure, weeds grow and obstacles accumulate. Hence, the TSAG must clean the ditches at least once in the beginning of the season. However, the demand for cleaning still depends on the design of the farm ditches.[14] In this regard, the requirement for cleaning and maintenance may not be as strong as the need for a meeting.

4.5.2. Determinants of high management attendance rates

Having noted its importance, the question of how to increase attendance in management activities naturally arises. This subsection aims to identify the factors underlying the attendance rate in each activity by means of an OLS regression analysis. We used the data of 139 TSAs on attendance rate and the TSA characteristics in the last season of our survey (Season 4).[15]

We selected TSA characteristics as explanatory variables based on existing literature on collective action and our field observation. Descriptive statistics are presented in Table 11. The literature suggests that group homogeneity is important for collective action. We observed that TSAs consisting of different barangays face more difficulty in gathering people, particularly when some barangays are located far from the TSA. In this regard, as the first group of our explanatory variables, we constructed (1) the number of barangays in a TSA, (2) the Herfindahl index of barangay composition, (3) the proportion of members from the dominant barangay, (4) the proportion of members from the barangay(s) within 1 km of the dominant barangay. We used these variables alternatively in our regression model. The second group of variables measured the size of the TSA. We used TSA area and number of water users (sum of registered and non-registered users) in a TSA. The third group of variables intended to capture the impact of the existence of independent water managers, which is measured by the number of water tenders appointed by a TSA per hectare of TSA area. The fourth group of variables

[14] For example, demand would be high if the length is considerable, siltation speed is high, and fragility of earth structure is high.
[15] Because of merging and abolition, sample size was reduced to 139 in the last season.

controlled tenancy by proportion of CARP farmers, proportion of owner cultivators, proportion of absentee landlords, and proportion of farmers who cultivate mortgaged-out land. The fifth variable group controlled volumetric pricing intervention. The sixth group variables consisted of location dummies: down portion of main canal, downstream of up/down portion of main canal, and downstream of laterals. An econometric concern is the possible endogenous problem of number of water tenders, which we leave for a future research agenda.

In addition to these variables, we introduced a dummy variable that takes a value of 1 if a TSA has structural problems in its turnout and water control problems in the farm ditches. Following the recommendation of a water engineer, we defined this variable as TSAs whose recorded water volume exceeded 30,000 m^3/ha for any season. This threshold value is chosen because, given the capacity of the designed turnout, the volume exceeding this threshold value indicates that turnouts and farm ditches have structural problems and water cannot be properly controlled by a spindle gate attached to a turnout. Note that the recorded high volume of these TSAs does not necessarily mean that they use that much water because the washout is a part of the structural problem. Under such a condition, the motivation to have proper water management may be different from that of other ordinary TSAs because the water flows into their area regardless of management efforts. Among the 139 TSAs in our sample, 36 (26%) were identified as having structural problems. As mentioned earlier, the common problems identified in our survey are those related to the farm ditches. To make our estimation model flexible, we introduced not only the dummy variables but also the multiplicative terms with all the other explanatory variables.

Table 12 shows the results explaining the attendance rate of TSA meetings. A key finding from the homogeneity variable was that the fewer and closer the barangay composition was, the higher the attendance rate. This is an important implication for the design of the canals as well as the location, size, and water boundary of the TSAs. Another important result was that the coefficient of the number of water tenders per hectare was positive and statistically significant. When water tenders are appointed, TSA members delegate the authority of water control to the water tender, which contributes to equitable water allocation. Our regression results probably captured the association between the TSA members‘ higher motivation in water management (by appointing water tenders) and high attendance rate. As discussed earlier, volumetric pricing gives an incentive to use water more efficiently. This would be the reason for the positive and significant confidence level for that variable.

Note that, as indicated by the interaction terms, the results show that the existence of structural problem nullified the effect of homogeneity, water tender, and volumetric pricing.[16] This implies that, unless infrastructure is in good condition, the mechanism of collective management does not function as well as do the others. The repair of malfunctioning farm ditches is essential among active TSAs.

Table 13 presents the results regarding attendance in cleaning and maintenance activities. Compared with the previous result, we had much fewer significant variables. This may be because cleaning is not a necessary precondition for all TSAs. Hence, we take these models as just supplementary results explaining the mechanism of collective management. A puzzling result pertains to the non-significant coefficients of homogeneity indexes. Meanwhile, a positive and significant coefficient of TSA size showed that the higher the demand for cleaning, the higher the attendance rate. The negative sign of TSA member may have captured the tendency for a free ride within a large group. Again, a strong association with the number of water tenders was found.

4.6. Comparison between different groups of farmers

In this section, we compare the degree of water stress as well as the other resulting outcomes by landholding, asset position, tenure status, and gender of household head. Since we have found the existence of structural problems in turnouts and farm ditches in about one-fourth of the TSAs, we also make a comparison between normal TSAs and problematic TSAs. In sections 4.2–4.4, we have already found that the downstream along the laterals as well as the downstream parcels in the TSAs tended to suffer from water stress more often. Therefore, even if we find an association between frequent water stress and small landholdings, for instance, it may simply capture the fact that we observed more small holdings in the downstream along the laterals (or downstream in the TSAs). Therefore, in Table A1 in the appendix, we show the *t*-test results of the mean differences of grouping variables (1) between downstream and upstream along the laterals and (2) among upstream, midstream, and downstream in the TSAs.[17] A significant difference was found in the proportion of female-headed households in the TSA and the existence of problematic TSAs along the lateral, which will be taken care of in our interpretations in the corresponding section below.

4.6.1. Landholdings

We divided the farmers at the median landholding size of 1.154 ha. Figure 57 shows that large farmers were prone to experience more frequent water stress during drought season.

[16] The sum of the coefficients of the original variable (homogeneity variable, water tender, or volumetric pricing) and the interaction term was not statistically significant for all the mentioned variables for all models.
[17] Differences along the main canal are not shown as we did not detect statistical differences in water stress along the main canal (Section 4.2).

This implies that landholding size is not associated with the power to access water. Rather, from a hydrological point of view, they experience difficulty in irrigating their field entirely. As to equity in resulting outcomes, Figures 58 and 59 show that small farmers achieved significantly higher yield in normal years (seasons 1 and 3), and achieved significantly higher rice income per hectare in Season 1. This is consistent with the stylized fact of the advantage of small farmers in rice farming. Meanwhile, the comparison of per capita household income (Figure 60) and asset value (Figure 61) showed that these values were by far higher among the large farmers, indicating that the high productivity of small farmers does not contribute much to fill the gap between them and the rich large farmers.

4.6.2. Asset position

The same comparisons were made between asset-rich farmers and non-rich farmers, (divided at the median of 4,100 Pesos per capita). We did not find any significant disadvantage for the non-rich in terms of water stress (Fig. 62). In contrast to the landholding case, yield was significantly higher for the asset-rich farmers, except for Season 2 (Fig. 63). The same was true for rice income per hectare, except for Season 4 (Fig. 64), although p values were smaller. Similar to the previous case, household income per capita was significantly higher for the asset rich and the gap between the two groups seems not to have narrowed yet.

4.6.3. Tenure

We compared three groups of tenancy status of the survey parcels: (1) owner cultivators, (2) CARP owner-cultivators, and (3) non-owner-cultivators consisting of share or lease tenants or mortgaged-in cultivators. Figure 66 shows that CARP farmers tended to suffer more frequent water stress, in particular during Season 3, with a statistically significant difference. An anecdotal evidence we observed is that the ex-landlords, who usually retain upstream parcels along the laterals in the TSAs, hold onto irrigation water as much as possible as their vested interest, resulting in water shortage being experienced by downstream CARP farmers. Meanwhile, these landlords will not cause this kind of hardship to their current tenants as rent from the tenants possibly depends on their water access. Figures 67–69 show the disadvantages of CARP farmers in terms of yield (particularly in Season 3 when water stress of CARP farmers was statistically significant), per-hectare rice income and per-capita household income, although in many cases, these were not statistically significant. Meanwhile, in terms of total asset value per capita (Fig.

70), faster growth among CARP farmers was seen, even if statistical significance among the groups was quite weak.

4.6.4. Gender

Figures 71 to 74 compare male-headed households and female-headed households. Note that the latter group consisted of about 4% of our sample households in the irrigated area. Yield, water stress, and rice income per hectare were not significantly disadvantageous in the latter group. Although the female-headed group's per capita income (Fig. 74) and asset value (Fig. 75) were significantly lower in the first two seasons, the figures show a quick catchup in the last two seasons. In this regard, we would like to argue that we do not observe a strong evidence of disadvantage in the female-headed households. These results are consistent with conventional wisdom because females are generally not segregated socially and economically in the Philippines. However, it is still better to keep in mind that the potential disadvantage of female-headed households *per se* may be masked because, according to Table A1, they are more likely to be located in the up- or midstream in the TSAs, rather than downstream.

4.6.5. Structural problems of turnouts and farm ditches

The TSAs with structural problems are identified in Subsection 4.5.2, but we found no significant difference in water stress between TSAs with normal structure and those with problematic structure (Fig. 76). Since we have more problematic TSAs in the upstream (21 % vs 12%) along the laterals (Table A1), we cannot deny the possibility that the abundance of water in the upstream masked the water stress problem of these TSAs. Figures 77 and 78 show higher yield and rice income among the TSAs with structural problems in the drought season. Nevertheless, Figures 79 and 80 indicate that this yield difference does not result in a difference in income and asset. These results reveal that the existence of structural problems is a problem in itself in the sense that it collapses collective management (as shown in the previous section) or makes water savings not feasible (as shown in the next section). However, as long as we are concerned about key outcomes, it seems not to seriously create negative outcomes.

4.7. Impact of volumetric pricing system

A kind of volumetric pricing system was randomly assigned to half of the TSAs. Figures 81–86 assess the impact of this intervention on the different aspects of water use and related indicators over the survey period. Note that Season 0 was the base year with no intervention and that seasons from 1 to 4 had been under intervention. Note also that, following the recommendation of a water engineer, we have dropped 21 TSAs from the analysis in seasons 0 and 1 (when data were collected only from upstream of the main canal) and 36 TSAs in seasons 2 to 4 (when data were collected from the entire canal) based on the criterion that we explained in Subection 4.5.2 (i.e., recorded water volume should not exceed 30,000 m^3/ha for any season). Since controllability of water inflow is a precondition of water savings under volumetric pricing, we have decided to drop such TSAs from our analysis.

Figure 81 on water volume used by the TSAs shows that the two groups started with the same amount of water use in Season 0, and both had used almost the same amount until Season 2. Note that, in Season 2, water use of both groups went up to cope with a drought shock. From Season 3, however, the volumetric group seemed to start learning how to save water collectively, and the savings had become more discernible toward the end of the survey. Nevertheless, the difference was not statistically significant. The impact could have been significant if our pricing system provided not only a reward to water savings but also a penalty to overuse, or if we set the reward rate higher.

Figure 82 shows the TSA's average AWD score, which was developed to measure the degree of AWD practice (see Table 10 for the definition). The score takes a value from 0 to 1, with 0 indicating there always existed standing water at the time of water application during the period that instructions on AWD recommend drying of the field and with 1 indicating that the soil was always dry at the time of water application during the previously mentioned period. The AWD score was significantly higher for the volumetric TSAs in seasons 3 (at 10% *p* value) and 4 (at 5% *p* value), indicating a significant impact of volumetric pricing on AWD practice.

In water savings, at the same time, farmers are not supposed to give too much water stress to paddy. To explore this concern, using the water stress index we earlier constructed (*dryf_4060)*, Figure 83 shows the frequency of water stress, by group. The volumetric group experienced more water stress in the drought season and the third season, although the differences were not statistically significant. We further examined whether that water stress resulted in yield loss. For this purpose, Figure 84 shows the TSA average yield over the survey period, by group. Average yield of TSA was always lower among the volumetric TSAs, becoming barely significant at 10% in the drought season (Season 2). In this season, the volumetric group seemed to save water to the extent that they suffered from yield loss. This turns our attention to the importance of training farmers on proper and safe water-saving methods.

Figure 85 compares the TSA average water productivity, defined as paddy output (kg) per m^3 of water consumed; we expected higher water productivity among the volumetric group, but, since their yield is lower, we were not able to find evidence to show high water productivity.

Figure 86 shows the impact on TSA average rice income per hectare of survey parcels. Note that in our pricing system, a bonus was paid to theTSA as a reward for the group effort, rather than to individual farmers. Hence, the savings, under our system, do not have a direct tangible impact on the household budget. Therefore, upon analyzing the lower yield among the volumetric TSAs (in particular in Season 2), rice income per hectare was also lower, particularly in period 2 (this was statistically significant). This reminds us again of the importance of training on safe water savings.

4.8.Impact on social values

4.8.1. Sample

To make the sample size manageable for the game experiment, we have randomly selected a subsample of armers from our original sample in the irrigated and rainfed areas from either of the two feasibility studies. In sampling, we have encountered the problem of not being able to obtain a sufficient number of sample farmers only from the area inside of the FSs in order to making pairs for game transactions among the rainfed farmers. We thus added eight farmers from Barangay Guinobatan, which is outside of FSs, just for this purpose. We have dropped these eight farmers from our analyses: we now had 160 irrigated rice farmers and 147 rainfed rice farmers. Of the former, 86 farmers were exposed to volumetric intervention and 74 were under area-based pricing. Table 14 shows our sample by barangay, in the irrigated and rainfed areas.

4.8.2. Types of games conducted

To capture the different aspects of social values and behavioral rules, we have conducted nine types of games. A brief explanation of each game is given below. The aspects intended to be measured by the games are shown in the parentheses beside the name of the game. More details on the contents of each game are explained in the supplementary documents of this report.

- Dictator Game (*altruism*)
  Transfer of P100 to a specified partner who has no initial endowment.
- Ultimatum Game (*fairness*)
  Rejection point of the transfer from a specified partner who could send P100 at max. Rejection makes both parties payoff zero.
- Trust Game-Sender (*trust*)
  Transfer of P100 to a specified partner. The partner will receive tripled amount and asked to return money back to the sender.
- Trust Game-Return (*trustworthiness*)

Return of received amount to the sender.

- Donation Game (*altruism to a group*)
  Donation out of P100 to the mentioned group
- Public Goods Game (Regular) (*cooperation/collective action*)
  Investment out of P100 to the mentioned group. Total investment will be doubled and equally shared among the members.
- Public Good Game with Punishment (*opportunism/tendency of free-riding/tendency to use punishment*)
  After the first round of the regular public goods game, each participant has the option to check the other three members' investment at the cost of P1 and send an ―unhappy face" message to members whose contribution the participant thinks is not enough at the cost of P1 per message.
- Risk Game (*risk attitude*)
  Bet P100 with the return of *0, *0.5, *1, *1.5, *2, *2.5 at 1/6 probability each.

To investigate differences in behavioral rules toward different types of partners, we have adopted a strategy method in our games, specifying the partner listed below in each case of transfer (except for the risk game, which has no partner in transactions).

- For the games of bilateral transaction (dictator, ultimatum, and trust), a partner is specified as follows:
  - Somebody in your purok
  - Somebody in your barangay
  - Somebody in your municipality
  - TSA member in your barangay (irrigated only)
  - TSA member in a different barangay (irrigated only)
- For the games played by a group of people (donation and public), a group is specified as follows:
  - Four people in your purok
  - Four people in your barangay
  - Four people in your municipality
  - Four people in your TSA (irrigated only)

In addition to these games, we have conducted *repeated* public goods game to the subsample of 62 farmers of our game sample farmers, in which 30 were from irrigated areas (16 volumetric and 14 area-based) and 32 were from rainfed areas. Among the different kind of group, we have used only the case of ―four people in barangay" because it is the most common setting in the provision of local public goods. In the experiment, the participants played three rounds of the public goods game without a punishment option and then three more rounds of the same game with a punishment option. This game will reveal the evolution of contribution to public goods with and without the punishment option.

4.8.3. Results

Table 15 shows the results of the games (except for the repeated public goods game). The *t*-test results of mean difference between the volumetric group (column 1) and the area-based group (column 2) are indicated by asterisks in column 2, and the same tests between the irrigated group (column 3) and the rainfed group (column 4) are in column 4. Statistical examinations among the partners are shown in the table or explained in the footnotes. The key features are summarized thus:

- In general, the amount of transfer decreases as the specified partner belongs to a wider geographical area (i.e., purok→ barangay → municipality). This holds true in the public goods game in the irrigated area.[18] Hence, we may take this result as another supportive evidence for our claim that collective management can be better organized by fewer and closer barangays.
- The transfers in the dictator game were significantly lower among rainfed rice farmers and those in the ultimatum games were significantly higher in the rainfed area. This indicates lower altruism but greater fairness in rainfed areas than in irrigated areas. The lower altruism value may be simply due to lower income in rainfed area. Meanwhile, higher fairness may stem from the strict risk-sharing discipline among rainfed farmers who are under a riskier environment in the rainfed area.
- Comparing between the transfer to ―TSA member in your barangay" and that to ―TSA member in a different barangay," we found that the latter basically received a lower transfer, although the difference was statistically significant only for the dictator game (at practically 0% of *p* value). If altruism can be part of the reason for participation in collective management, this result confirms our previous finding that collective management becomes more difficult as more members come from different barangays.
- However, in the same comparison in the trust game return (trustworthiness) between the volumetric group and the area-based group, the difference disappeared in the volumetric group (*p* value of 81%), while it was weakly significant in the area-based group (*p* value of 10%). This may imply that, once the volumetric group received a transfer (being trusted) from a TSA member in a different barangay, they behave

[18] The following *t*-tests were conducted: (1) Purok=Barangay, (2) Purok=Municipal, (3) Purok=TSA, (4) Barangay=Municipal, (5) Barangay=TSA, (6) Municipal=TSA. All were statistically significant at least at 5%, except for cases (3) and (4).

trustworthy, even to that group of people. Through collective management in real life under the volumetric incentive, they may have learned how to construct a trustworthy relationship even with the group of people they were not familiar with before.

- In the trust game, rainfed rice farmers received almost the same amount (P126) as did the irrigated rice farmers(P123) and they were not statistically significant. But, the rainfed rice farmers returned much less (in the range of P35–39 for different partners, vs P43–47). These differences were statistically significant at 5% or 15%. One possible reason for this may be that, under the risky environment in the rainfed area, the transfer may be interpreted as a gift in case of an emergency, rather than an investment as the game has originally designated. The social value ―*utang na loob*” may be behind this behavior, providing an excuse that a feeling of indebtedness is important, rather than immediate return. Nevertheless, this conjecture must be examined with a control for income difference between irrigated and rainfed rice farmers.
- The transfer amount in the donation game was higher in the order of volumetric, area-based, and rainfed groups. Although all differences (except the one in rainfed) were not statistically significant, this might imply that differential degrees of solidarity among the groups are emerging. We suppose that solidarity has been developed through their experience of collective management in real life--thus it was higher in the order of volumetric, area-based, and rainfed groups.
- Although differences were marginal and much less statistically significant, the same pattern was found in the results of the public goods game. The same reason may apply here, too.
- In the public goods game with a punishment option, one distinctive feature was the volumetric group checking the results much more often (significant at 1%) and sending more punishment messages (significant at 5%) to the low-contribution members (i.e., the free riders) than the area-based groups. This may reflect strictness in real life with respect to collective irrigation management.
- The risk game results show that rainfed farmers seem to be more risk-averse (significant at 15%).

Table 16 shows the results of the repeated games with *t*-test results presented in the same format as the previous table. Using the results in the table, Figure 87 depicts the evolution of the transfer between irrigated and rainfed groups. These are the key findings:

- Similar to the non-repeated public goods game, we found more result checks by the volumetric groups in general. However, partly because of smaller sample size, we seldom found statistically significant differences.

- We found a progressive contribution over rounds in general, indicating the existence of a virtuous cycle in our study area. However, we are not sure if this always holds true because this feature may depend on the result of the first-round game.
- Figure 82 indicates that the rainfed group started at low contribution but approached that of the irrigated group over several rounds. Even among the rainfed group, which had few opportunities for collective action, seemed to learn quickly an appropriate strategy once the opportunity to do so is given.
- We observed a drop or a stagnation of contribution in the last round. Probably, the participants noted that this was the last round and free riding was not punished anymore.

4.8.4. Determinants of meeting attendance rate revisited: distance or composition?

Some of the findings above necessitated a deeper examination of the determinants of TSA management activities. One game result showed that the farther the distance, the weaker the tie is. Another game result showed that the ties with people in different barangay was weaker. However, it was also shown that a weaker tie could be strengthened if opportunities to do so were given. In this regard, we may infer that the ties between people in close barangays may be not so weak, even if they belong to different barangays, at least to the extent that collective management does not deteriorate. This argument may be acceptable as it is in line with the argument of ―loosely structured" villages. If this is the case, the composition of a TSA does not matter as long as the barangays are located close to each other.

Meanwhile, a key finding regarding determinants of meeting attendance rate is that the fewer and the closer the barangays are, the higher the attendance rate. Given the conjecture based on the game results, it is better to distinguish between distance and composition. Practically, this distinction is very important in designing an irrigation system because it determines the optimal size, location, and water boundary of the TSAs.

To examine this point, we introduced an additional explanatory variable, defined as the number of member barangays located within 1 km from the dominant barangay. The coefficient of this variable becomes negative and significant if diversified composition matters, even if barangays are near each other.

We likewise introduced another set of variables. Since the game results show that volumetric pricing provides an opportunity to get the barangays to work together, we examined this point by introducing a multiplicative dummy with the number of member barangays within 1 km as well as the proportion of members from the barangay within 1 km. We expect a positive and significant coefficient on the former term, indicating that, under volumetric pricing, the negative impact of a diversified barangay composition is weakened. Other explanatory variables, including the dummy of structural problem, were the same.

Table 17 shows the OLS regression results. In either model, the proportion of member within 1 km was still highly significant with a positive sign. Meanwhile, the composition of barangays was not significant, although it has a negative sign. This implies that, as long as members are located close to each other, it does not matter from which barangays they come from. Model (2) with the multiplicative term showed no significant impact of volumetric pricing, although the sign was positive as we have expected.

In short, our data indicate that distance matters but composition does not. Nevertheless, we still refrain from a generalization of this claim beyond the Bohol case because social ties may work differently in other places, even within the Philippines. As this is an important issue for a better design of irrigation systems, conducting a comparative analysis over different irrigation systems over a wider area is worth doing.

5. Summary of findings and recommendations

This report has evaluated the multifaceted aspects of the impact of the Bohol Irrigation Project (Phase 2) and has offered recommendations for a greater and more sustainable impact for the future. Our findings on each aspect are summarized below in black bullets. When problems are identified in the findings, recommendations are made in white subbullets.

(1) Impact of irrigation project

- Irrigation transformed rice farming from a traditional style to a high-input-high-return system. Over the survey period, the average paddy yield of irrigated rice farmers was about twice as high as that of rainfed rice farmers (2.4 t/ha per season of dry paddy against 1.2 t/ha per season). As to inputs, irrigated rice farmers used about 1.5 times more chemical fertilizer than did the rainfed rice farmers; irrigated rice farmers have started to use hybrid rice varieties.
- This transformation has resulted in a higher rice income of irrigated farmers compared with the counterfactual rainfed farmers (about 2.4 times higher over the seasons).
- Another benefit of irrigation is reduction in risk against drought. However, in the project area, even irrigated rice farmers suffered from a negative shock of flood.
- As a result, irrigated rice farmers were able to achieve higher and more stable income (except during the flood season), which contributed to the faster growth of household assets.

- However, it is better to note that rainfed rice farmers had non-agricultural income sources and they earned more from these sources than did the irrigated rice farmers. This made the income gap between the two farmer groups smaller.

(2) Equitable water access and resulting outcomes among irrigated rice farmers

- We did not find any statistical difference in water access as well as in key outcomes (such as yield, income, and asset value, etc.) along the main canal. This indicates that the main canal is properly designed and constructed to the extent that the system is supposed to irrigate the current service area (about 2,600 ha) and that NIA has been properly maintaining and managing the facilities they are supposed to take care of. Also, we did not find strong evidence of the differences in water access and outcomes among small landholders, asset non-rich farmers, non-owner cultivators, and female-headed households.
- Meanwhile, we did find disadvantages in terms of water stress, yield, and equal water access among farmers in the downstream portion of the laterals. Since the laterals are lined throughout the system, seepage loss cannot be the reason for the water shortage downstream. Rather, this problem is mainly attributed to failure in equitable water rotation among the TSAs along the laterals.
    - IAs are in charge of water rotation along the laterals. Hence, strengthening of IAs to enable them to implement a stricter water rotation could be a solution to this problem. For this purpose, we may draw lessons from JICA‘s experience in the rehabilitation of the Bago River Irrigation System in Negros, where the downsizing of IAs on the basis of actual water boundaries significantly improved water rotation and reduced water conflicts among the TSAs. In fact, the reform of the IAs initiated recently by NIA in this system is in line with Bago‘s experience, and could thus contribute to an improvement in water rotation.
    - The repair of malfunctioning farm ditches is important in the implementation of stricter water rotation because it makes water inflow more controllable by TSAs. As of the end of the survey in 2011, about 20% of the TSAs potentially suffer from farm ditch problems such as water washout due to shallowness or sharp curvature of ditches or stagnation due to impounding. Since the design, construction, and maintenance of the farm ditches are among the TSAs‘ responsibilities, these problems must be solved on their own initiative. Even in this case, however, collaboration with NIA is still important because the lack of hydrological knowledge for ditch design and the lack of manpower and budget for ditch excavation and lining are main bottlenecks in the TSAs. In line with this, NIA has already started the validation of farm ditch lining with

NIA's own budget (a total of 23 km of lining with 46 million pesos in 2012). This would facilitate stricter water rotation. [19]

- Differences in outcomes were found also in the water allocation scheme within a TSA, where upstream parcels achieved higher rice income per hectare by taking advantage of a hydrological privilege, particularly in a drought season.
    - TSAs with high attendance in TSA meetings as well as in cleaning activities seem to show better performance in terms of equitable and assured water access. To have higher attendance rate, our regression analyses and game experiment on social values indicate the following aspects to be crucial. First, the absence of infrastructural problems is essential to a better management of the TSA. Second, TSAs must be formed by members located close to each other. The diverse composition of the barangays does not matter as long as the members are located near each other. The location of turnouts and associated boundaries of TSAs must be so designed taking into account this aspect.
- Although the statistical significance is weak, it is still better to pay attention to the possible disadvantages that CARP farmers (the land reform beneficiaries) have. Our data show that their water access was slightly worse than the others possibly because of their weak social position relative to their ex-landlords who sometimes try to occupy irrigation water as their vested interest.

(3) Impact of volumetric pricing

- Under the volumetric incentive (bonus reward system) we randomly introduced, TSAs that did not have infrastructural problems of water control at the turnout level have gradually reduced their water use but this reduction was not statistically significant.
    - The impact could have been significant if our pricing system provided not only a reward to water savings but also a penalty to overuse, or if we set the reward rate higher.
- There are concerns that volumetric groups saved water too much to the extent that they had yield losses during the drought season.
    - Training farmers on safe water saving would be effective and so would a training on safe AWD.

In short, the Bohol Irrigation Project (Phase 2) substantially improved the livelihood of the beneficiary farmers by enabling them to earn higher and more stable income from rice production than the counterfactual rainfed rice farmers. To achieve

[19] Social problem can be another reason for problematic farm ditches. For example, some landowners do not want a farm ditch passing through their field. It is not easy to find a solution to this kind of conflict, but NIA's involvement may be important also in this case because NIA can make recommendations as the official agent independent of any groups of the farmers.

equitable outcomes within the system, our analysis found that the role of IAs and TSAs are crucial. The performance of IAs and TSAs depends on the structure of the group. For example, IA management could be more effective if coverage of the IAs were small enough to be consistent with the actual water boundary. TSA management would be more active if the members of a TSA were geographically close to each other. Moreover, functioning farm ditches are important in ensuring better IA and TSA performance. Hence, in line with the ongoing reforms and repair by NIA, continuous efforts to fulfill the abovementioned conditions would further contribute to more equitable outcomes. Note, however, that since these conditions could be met at the expense of hydrological efficiency, we have to consider the net gain from doing so. Another way to guide farmers to achieve better water management may be the use of volumetric incentive as it encourages water savings and the water saved by some TSAs can be used by other water-deficit TSAs. Note, however, that we can use this approach only when infrastructure allows volume measurement and inflow control at the TSA level. Again, a functioning farm ditch system is imperative. Since there is a risk of yield loss in the case of extreme water savings, it is better to implement volumetric pricing along with training on safe water saving.

In the long run, the adjacent rainfed area could get positive impact from the project though an increase in demand for agricultural labor, increase in demand for casual services, or a decrease in rice price (if rainfed rice farmers were net buyers). Although such impacts have yet to be observed during our survey period, the evaluation of these indirect impacts would be an important future agenda for comprehensive impact assessment.

Lastly, although we have revealed the importance of the IAs and the TSAs, the validity of our lessons for better management is limited because we rely on the evidence from one irrigation system. Conducting a comparative analysis of different irrigation systems under different conditions with different performance levels is worth trying in order to come up with a more generalized statement of lessons for the benefit of future irrigation undertakings.

6. References

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Table 1. Features of the Bohol Irrigation System.

Characteristic	
Composition	Malinao Irrigation Capayas Irrigation Bayongan Irrigation
Location of dam	Malinao - Pilar Bayongan - San Miguel Capayas - Ubay
Dam type	Malinao - Reservoir Bayongan - Reservoir Capayas - Reservoir Malinao, Bayongan, and Capayas dams are connected through a diversion canal Malinao Dam ---→ Bayongan Dam --→ Capayas Dam
Dam capacity (Active)	Malinao - 5 MCM Bayongan - 25 MCM Capayas - 3.5 MCM
Watershed area	Malinao - 127 sq km Bayongan - 11.6 sq km Capayas - 13 sq km
Designed service area	Malinao - 4960 ha Bayongan - 4140 ha Capayas - 1160 ha
Municipalities covered	Malinao - Pilar, Alicia, Dagohoy Bayongan - San Miguel, Ubay, Trinidad Capayas - Ubay
Start of operation	Malinao - 1996 Capayas - 1993

Table 2. Features of the Bayongan Irrigation System.

Characteristic	
Dam reservoir capacity	34.6 MCM
Dam active capacity	25 MCM
Dam reservoir area	
Watershed area	11.6 sq km
Designed service area	4140 ha.
Length of main canal	17.5 km
Number of laterals	15
Length of laterals	32.839 km
Number of sublaterals	4
Length of sublaterals	6.309 km
Number of turnouts	172
No. of add'l turnouts	57
Number of I.As	11 (21 downsized)
Municipalities covered	San Miguel, Ubay, Trinidad
Number of barangays covered	14
San Miguel	4
Ubay	8
Trinidad	2
Construction date	
Dam	2003
Main and lateral canals	2004
MFDs	2007 (Irrigators' Associations)
Make	
Dam	Earth dam
Main and lateral canals	Concrete line
MFDs	Earth canal
Start of operation	May 2008

Table 3: Time line of the irrigation system.

Year, month	Event
1985	Feasibility study
2001	Formation of IA and TSA
2004	Start of construction
2007Nov – 2008 Mar	Test run of the system (upstream laterals only)
2008 May	Start of operation (upstream laterals only) Test run of the system (downstream laterals)
2008 Nov	Start of IRRI-JIRCAS survey
2009 Dec	Change of rotation schedule
2010 Jun	Change of rotation schedule
2010 May	Downsizing of IA from 11 large IAs to small 21 IAs on the bases of lateral

Table 4: Irrigation schedule

Period	Days of dam opening and closing	Rotation	Remarks
0	2008 Nov 10 2009 March 11	• 14 irrigation intervals, • First 6 weeks, one interval = 6 days. • Following 80 days, one interval = 10 days. • In one interval, 3-day for upstream, then 3-day for downstream • 24 hours/day	Very high supply and difficult to monitor at night time
1	2009 May 25 2009 Sept 25	ditto	
2	2009 Dec. 15 2010 April 24	• 10 irrigation intervals, • One interval = two weeks. • In one interval, 6-day simultaneous irrigation and 8-day no water. • 12 hours/day (only daytime)	Low supply, possibility of water shortage in downstream laterals
3	2010 June 23 2010 Nov. 6	• 11 irrigation intervals • One interval = two weeks • In one interval, fist 6-day for downstream and next 6-day for upstream • 12 hours/day	Moderate supply,
4	2010 Dec. 20 2011 May 7	• Minor change. 9 days of water release in first three intervals	Slightly higher than moderate supply

Table 5. Cropping pattern and productivity data before the irrigation project.

TABLE 3-5 PRESENT CROPPING PATTERN AND CROP PRODUCTION

Land/Crop	Phisical (ha)	Cropping Intensity (%)	Planted Area (ha)	Harvested Area (ha)	Yield (ton/ha)	Production (ton)
1. Paddy field	1,780	165	2,930	2,490[1/]	1.32	3,286
- Wet season rice	-	90	1,600	1,350[1/]	1.37	1,850
- Dry season rice	-	75	1,330	1,140[1/]	1.26	1,436
2. Upland field	1,900	53	1,000	1,000		3,554
- Sweet potato	-	23	430	430[2/]	2.02	869
- Cassava	-	30	570	570[3/]	4.71	2,685
Total	3,680	107	3,930			6,540

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Note: The planted area and the harvested area are estimated on the basis of the following figures (Physical area = 100%)

Crop	Planted area	Harvested area	Refered data
Wet season rice	90 %	76 %	BAEcon crop production data in Bohol (1974-84)
Dry season rice	75 %	64 %	- do -
Sweet potato	23 %	23 %	NIA Farm Management Survey, 1985
Cassava	30 %	30 %	- do -

Source: 1/ BAEcon crop production data (Bohol, 1974-84)
2/ BAEcon crop production data (Central Visayas, 1974-83)
3/ NIA Farm Management Survey, 1985

Source: JICA (1985)

Table 6. Survey schedule.

Year	2008	2008-09	2009	2009-10	2010	2010-2011	
Cropping season	**1st (May-Oct)**	**2nd (Nov-Apr)**	**1st (May-Oct)**	**2nd (Nov-Apr)**	**1st (May-Oct)**	**2nd (Nov-Apr)**	
Survey season	**Operation started**	**0**	**1**	**2**	**3**	**4**	
Survey module							
Water volume measurement		X (upstream only)	X (upstream only)	X	X	X	
HH data (irrigated)		X (upstream only)	X	X	X	X	
TSA module		X (upstream only)	X	X	X	X	
HH data (rainfed)			X	X	X	X	
Field experiment							X (150 irrigated, 150 rainfed)

Table 7. TSA, member size, and sample size.

TSA	TSA memeber size	Sample size	TSA	TSA memeber size	Sample size	TSA	TSA memeber size	Sample size
A-1	20	3	E-1	18	2	M-1	7	2
A-2	9	3	E-2	30	3	M-2	21	3
A-2a	7	2	E-3	19	3	M-3	19	3
A-3	29	3	E-4	9	3	M-4	25	3
A-4	33	3	E-5	19	3	M-5	30	3
A-5	22	3	F-1	19	3	M-6	10	2
A-6	61	3	F-10	19	3	M-7	18	3
A-7	19	3	F-3	13	2	N-1	35	3
A-8	9	2	F-4	12	3	N-2	14	2
A-9	8	3	F-5	21	3	O-1	0	3
A-10	18	3	F-6	28	3	O-2	29	2
A-11	14	3	F-7	19	3	O-3	10	3
A-12	29	3	F-8	27	3	O-4	15	3
A1-1	15	3	F-9	19	3	S-1	39	3
A1-2	28	3	F-11	9	2	S-1a	18	3
A1-3	70	3	F-13	21	2	BMC-1	12	3
A1-4	45	3	G-1	16	3	BMC-2	39	3
A1-5	23	3	G-3	11	3	BMC-3	24	3
A1-6	23	2	G-4/G-4a	8	3	BMC-4	25	3
A1-7	20	3	G-5/G-6	31	3	BMC-5	26	3
A1-8	19	3	G-7/G-8	12	3	BMC-7	25	3
A2-1	37	3	H-2/H-3	15	3	BMC-8	51	3
A2-2	11	2	H-4	62	3	BMC-9	33	3
A2-3	14	3	H-5	32	3	BMC-11	55	3
A2-4	26	3	I-1	11	3	BMC-12	18	3
A3-1	9	3	I-2	12	3	BMC-13	43	3
A3-2	25	3	I-3	13	3	BMC-14	44	3
A1-a1	25	3	I-4	41	3	BMC-15	20	3
A1-a2	20	3	J-1	9	3	BMC-17/BMC-19	16	1
A1-a3	17	3	J-2	26	3	BMC-18	6	3
B-1	21	3	J-3	5	3	BMC-19	16	2
B-1a	34	3	J-4	5	2	BMC-20	38	3
B-3	10	3	J-5	30	3	BMC-21	27	3
B-4	38	3	J-6	30	3	BMC-22/22A	13	3
C-1	23	3	J-7	21	3	BMC-23/G-2	20	3
C-2	23	3	K-1	28	3	BMC-24	16	3
C-3	4	2	K-2	60	3	BMC-25	11	1
C-4	23	3	K-3	37	3	MNC-26	11	2
D-1	16	3	L-1	23	3	BMC-27	16	3
D-2	13	3	L-2	27	3	BMC-29	17	3
D-3	29	3	L-3	17	2	BMC-30	36	3
D-4	9	3	L-4	37	3	BMC-32	28	2
D-6	12	3	L-5	21	2	BMC-33	24	3
D-7	25	3	L-6	39	3	BMC-35	31	3
D-8	10	3	L-7	11	2	BMC-39	15	3
D-9	15	3	L-8	12	2	BMC-40	14	3
D-9a	9	2	L-9	8	3	BMC-41	19	3
D-11	15	3	L-10	12	3	BMC-42	39	3
			L-11/L12	15	3	BMC-43	9	3
						BMC-44	36	3
						BMC-45	18	3
						Total	3251	418

Table 8. Rainfed villages included in the survey and sample size.

Village name	Sample size
Bugang	20
Camanaga	17
Mahagbu	33
Soom	84
Guinobatan	27
Hagbuyo	25
Humay-humay	48
La Union	37
La Victoria	30
M. Roxas	35
Pangpang	45
San Isidro	28
Total	429

Table 9. Mean-comparison of selected household characteristics in 2009 first season between irrigated and different categories of rainfed area.

	(1) Irrigated n=411[b]	(2) Rainfed Inside of FS n=211	(3) Rainfed Inside of FS (strict) n=118	(4) Rainfed Outside of FS n=216	(5)=(2)+(4) Rainfed All n=427
Panel A					
Household size (persons)	5.346	5.550	5.356	5.389	5.468
	(0.132)	(0.161)	(0.229)	(0.156)	(0.105)
Female members percentage (%)	0.472	0.499*	0.512**	0.483	0.491
	(0.0103)	(0.0121)	(0.0159)	(0.0121)	(0.00803)
Schooling years of HH head (years)	6.256	6.294	6.102	6.144	6.218
	(0.170)	(0.221)	(0.308)	(0.213)	(0.144)
Landholding size (ha)	1.203	1.280	1.161	1.022**	1.149
	(0.0530)	(0.0687)	(0.0857)	(0.0654)	(0.0448)
Livestock holding total value (PhP)	23,511	26,454	19,341+	23,858	25,141
	(1,876)	(2,161)	(1,892)	(1,641)	(1,270)
Non-agricultural asset total value (PhP)	28,748	27,847	25,503	30,894	29,389
	(2,243)	(1,919)	(2,446)	(5,310)	(2,676)
Proportion of land reform beneficiaries	0.560	0.531	0.627	0.389***	0.459***
	(0.0165)	(0.0326)	(0.0434)	(0.0314)	(0.0215)
Panel B[a]					
Yield under rainfed (yield of irrigated is taken from FS) (kg/ha)	1,320	1,316	1,517*	1,410	1,364
		(56.7)	(74.6)	(63.4)	(40.2)

Note:
Means and standard errors are computed with sampling weights.
Standard errors in parentheses.
*** denote significance at 1%, ** significance at 5%, * significance at 10%,and + significant at 15% in t-test of the mean difference between irrigated area and either category of rainfed areas.

a) The t-test examines whether the mean rainfed yield is equal to 1320 kg/ha, which is taken from the feasibility study of JICA (1985) and reported in Table 5 of this report.
b) To obtain standard errors for the t-test, we dropped seven observations because each is only one observation within its sampling unit (i.e., TSA).

Table 10. Impact indicators used in the study.

Variable name	Definition	Type of measured impact
yield	Dry paddy harvest per ha o survey parcel (kg/ha)	Productivity
kgnha	Application of nitrogen per ha (kg/ha)	Modern input use
dummy_hybrid	Use of hybrid rice variety (dummy)	Modern input use
rice_totalrevenue_ha	Revenue of rice production of survey parcel per ha (PhP/ha)	Rice revenue
rice_totalcost_ha	Paid-out cost of rice production of survey parcel per ha (PhP/ha)	Rice cost
rice_income_ha	Rice income per ha (revenue – paid out cost) (PhP/ha)	Rice income
dpyieldbrgy	Proportional difference of farm-level rice yield from barangay average yield	Variation of yield in barangay
dpyield	Proportional difference of farm-level rice yield from TSA average	Variation of yield in TSA
crop_income_ha	Income from all parcels excluding survey parcel per ha (PhP/ha)	Crop income
ag_income_cap	Survey parcel rice income + crop income per capita (PhP per capita)	Agricultural income
nonag_income_cap	Wage and salary income + remittance + rent + pension + food aid per capita (PhP per capita)	Non-agricultural income
hh_income_cap	Ag income + non-ag income per capita (PhP per capita)	Household income
agr_asset_cap	Agricultural asset value per capita (e.g., tractors)	Ag asset position
nonagr_asset_cap	Non-agricultural asset value per capita (e.g., TV)	Non-ag asset position
Total_asset_cap	Agr + non-agr asset value per capita	Total asset position
lv_asset_cap	Livestock asset value per capita (e.g., carabaos)	Livestock asset position
dryf_4050	Frequency of dry soil condition during 40-50 days after transplanting (flowering stage)	Water stress
wvha	Water volume used by TSA (m^3/ha)	Water use
awd	AWD score adw=(x*1)+(y*0.5)+(z*0) / (x+y+z) where x=the number of times a farmer irrigated when the soil was dry, y= the number of times a farmer irrigated when the soil was wet, z= the number of times a farmer irrigated when the soil had standing water	Degree of AWD practice

Table 11: Descriptive statistics of TSA management activities and TSA characteristics.

VARIABLE	(1) N	(2) mean	(3) sd	(4) min	(5) max
TSA Management Activities					
Meeting attended prop	139	0.542	0.356	0	1
Cleaning attended prop	139	0.659	0.305	0	1
TSA Characteristics					
TSA Homogeneity					
No. of brgys in TSA	139	3.367	1.720	1	9
Herfindahl brgy comp	139	0.643	0.219	0.170	1
Dominant brgy member prop	139	0.753	0.180	0.200	1
Within 1km brgy members prop	139	0.759	0.202	0	1
Size					
TSA area	139	13.04	8.871	1.370	46.74
TSA member	139	18.74	10.56	4	50
Water tender					
No. of water tenders /ha	139	0.116	0.117	0	0.730
Tenancy					
CARP prop	139	0.382	0.445	0	1
Owner cultivator prop	139	0.361	0.349	0	1
Absentee landlord prop	139	0.114	0.232	0	1
Mortgaged-out land prop	139	0.0272	0.104	0	1
Pricing					
Volumetric	139	0.489	0.502	0	1
Location of TSA					
Main-down	139	0.360	0.482	0	1
Main up/down-part down	139	0.561	0.498	0	1
Lateral-down	139	0.331	0.472	0	1
Infrastructure condition					
Structural problem dummy	139	0.259	0.440	0	1

Table 12: Results of OLS regression analyses explaining the attendance rate in TSA management meetings

VARIABLE	(1) Meeting attended prop	(2) Meeting attended prop	(3) Meeting attended prop	(4) Meeting attended prop
TSA Homogeneity				
No. of Brgys in TSA	-0.0391*			
	(0.0229)			
* str_problem	0.123*			
	(0.0678)			
Herfindahl brgy comp		0.291*		
		(0.169)		
* str_problem		-0.419		
		(0.403)		
Dominant brgy member prop			0.333*	
			(0.197)	
* str_problem			-0.475	
			(0.514)	
Within 1km brgy members prop				0.370**
				(0.178)
* str_problem				-0.833*
				(0.467)
Size				
TSA area	0.00471	0.00360	0.00322	0.00325
	(0.00646)	(0.00648)	(0.00649)	(0.00641)
* str_problem	0.00834	0.0176	0.0183	0.0201
	(0.0179)	(0.0169)	(0.0169)	(0.0163)
TSA member	-0.00273	-0.00393	-0.00383	-0.00414
	(0.00535)	(0.00533)	(0.00533)	(0.00527)
* str_problem	-0.0239*	-0.0183	-0.0180	-0.0195
	(0.0136)	(0.0132)	(0.0131)	(0.0131)
Water Tender				
No. of water tenders /ha	0.776**	0.789**	0.787**	0.739**
	(0.357)	(0.360)	(0.360)	(0.354)
* str_problem	-1.016*	-1.038*	-1.027*	-0.906
	(0.565)	(0.579)	(0.577)	(0.563)
Tenancy				
CARP prop	0.0401	0.0216	0.00961	0.0145
	(0.156)	(0.155)	(0.154)	(0.152)
* str_problem	0.166	0.233	0.250	0.278
	(0.301)	(0.300)	(0.299)	(0.294)
Owner cultivator prop	-0.0690	-0.0657	-0.0706	-0.0567
	(0.184)	(0.185)	(0.185)	(0.183)
* str_problem	0.707**	0.664*	0.671*	0.767**
	(0.340)	(0.341)	(0.342)	(0.355)
Absentee landlord prop	0.294	0.279	0.274	0.275
	(0.189)	(0.191)	(0.191)	(0.189)
* str_problem	0.173	0.172	0.178	0.273
	(0.400)	(0.405)	(0.405)	(0.406)
Mortgaged-out land prop	0.441	0.473	0.447	0.440
	(0.309)	(0.314)	(0.311)	(0.306)
* str_problem	0.302	0.0556	0.0750	-0.158
	(1.628)	(1.643)	(1.650)	(1.642)
Pricing				
Volumetric	0.183***	0.199***	0.199***	0.210***
	(0.0696)	(0.0719)	(0.0719)	(0.0718)
* str_problem	-0.191	-0.163	-0.159	-0.166
	(0.149)	(0.149)	(0.148)	(0.144)
TSA Location				
Main-down	-0.191**	-0.200**	-0.199**	-0.214**

	(0.0849)	(0.0862)	(0.0863)	(0.0862)
* str_problem	0.296*	0.328**	0.332**	0.350**
	(0.154)	(0.156)	(0.155)	(0.153)
Main up/down-part down	-0.149**	-0.147*	-0.146*	-0.142*
	(0.0743)	(0.0749)	(0.0751)	(0.0743)
* str_problem	0.0669	0.0771	0.0765	0.0647
	(0.142)	(0.142)	(0.142)	(0.141)
Lateral-down	0.0232	0.0194	0.0209	0.0106
	(0.0738)	(0.0744)	(0.0744)	(0.0739)
* str_problem	-0.241	-0.204	-0.202	-0.197
	(0.164)	(0.164)	(0.163)	(0.160)
Infrastructure				
Str_problem	-0.285	0.143	0.204	0.432
	(0.381)	(0.547)	(0.621)	(0.518)
Constant	0.574***	0.292	0.239	0.217
	(0.180)	(0.230)	(0.253)	(0.236)
Observations	139	139	139	139
R-squared	0.262	0.252	0.251	0.267

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 13: Results of OLS regression analyses explaining participation rate in TSA farm ditch maintenance and cleaning activities

VARIABLE	(1) Cleaning attendance prop	(2) Cleaning attendance prop	(3) Cleaning attendance prop	(4) Cleaning attendance prop
TSA Homogeneity				
No. of Brgys in TSA	-0.00565			
	(0.0191)			
* str_problem	0.0375			
	(0.0566)			
Herfindahl brgy comp		0.116		
		(0.140)		
* str_problem		-0.0106		
		(0.334)		
Dominant brgy member prop			0.126	
			(0.163)	
* str_problem			0.104	
			(0.425)	
Within 1km brgy members prop				0.209
				(0.148)
* str_problem				0.0314
				(0.388)
Size				
TSA area	0.0146***	0.0144***	0.0143***	0.0142***
	(0.00540)	(0.00536)	(0.00536)	(0.00533)
* str_problem	-0.000979	0.00390	0.00467	0.00259
	(0.0149)	(0.0140)	(0.0139)	(0.0136)
TSA member	-0.0139***	-0.0141***	-0.0140***	-0.0141***
	(0.00446)	(0.00441)	(0.00441)	(0.00438)
* str_problem	-0.0183	-0.0159	-0.0162	-0.0153
	(0.0113)	(0.0109)	(0.0109)	(0.0109)
Water Tender				
No. of water tenders /ha	0.825***	0.841***	0.840***	0.822***
	(0.298)	(0.298)	(0.298)	(0.294)
* str_problem	-1.531***	-1.505***	-1.486***	-1.539***
	(0.471)	(0.479)	(0.477)	(0.468)
Tenancy				
CARP prop	0.168	0.179	0.173	0.184
	(0.131)	(0.128)	(0.127)	(0.126)
* str_problem	-0.0619	-0.0356	-0.0260	-0.0648
	(0.251)	(0.249)	(0.247)	(0.244)
Owner cultivator prop	0.129	0.144	0.141	0.158
	(0.153)	(0.153)	(0.153)	(0.152)
* str_problem	0.0824	0.0419	0.0338	-0.0280
	(0.284)	(0.282)	(0.283)	(0.295)
Absentee landlord prop	0.231	0.227	0.226	0.225
	(0.158)	(0.158)	(0.158)	(0.157)
* str_problem	-0.299	-0.285	-0.275	-0.337
	(0.334)	(0.335)	(0.335)	(0.338)
Mortgaged-out land prop	0.205	0.237	0.225	0.237
	(0.258)	(0.260)	(0.257)	(0.254)
* str_problem	0.572	0.528	0.598	0.638
	(1.359)	(1.361)	(1.364)	(1.364)
Pricing				
Volumetric	0.0433	0.0539	0.0530	0.0656
	(0.0581)	(0.0595)	(0.0595)	(0.0596)
* str_problem	-0.00816	0.0126	0.0173	-0.00710
	(0.125)	(0.123)	(0.122)	(0.119)
TSA Location				

Main-down	-0.113	-0.122*	-0.121*	-0.134*
	(0.0709)	(0.0714)	(0.0713)	(0.0716)
* str_problem	0.169	0.198	0.198	0.204
	(0.129)	(0.129)	(0.128)	(0.127)
Main up/down-part down	-0.123**	-0.119*	-0.119*	-0.114*
	(0.0620)	(0.0620)	(0.0621)	(0.0617)
* str_problem	0.0334	0.0327	0.0315	0.0321
	(0.118)	(0.118)	(0.118)	(0.117)
Lateral-down	0.115*	0.112*	0.113*	0.105*
	(0.0616)	(0.0616)	(0.0615)	(0.0614)
* str_problem	-0.244*	-0.216	-0.213	-0.212
	(0.137)	(0.136)	(0.135)	(0.133)
Infrastructure				
Str_problem	0.425	0.431	0.330	0.442
	(0.318)	(0.453)	(0.513)	(0.430)
Constant	0.536***	0.433**	0.417**	0.349*
	(0.151)	(0.191)	(0.209)	(0.196)
Observations	139	139	139	139
R-squared	0.300	0.302	0.303	0.312

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 14: Sample for the game experiments, by barangay, in irrigated and rainfed areas.

Barangay name	Frequency	Percent (w/in subgroup)
Irrigated		
BAYONGAN	24	15.0
BULILIS	24	15.0
CAMALIAN	16	10.0
CAMBANGAY NORTE	16	10.0
CATOOGAN	7	4.4
CORAZON	24	15.0
GABI	16	10.0
HAMBABAURAN	8	5.0
PAG-ASA	8	5.0
SAN VICENTE	8	5.0
TUBOG	9	5.6
Subtotal (irrigated)	160	100
Rainfed		
BUGANG	8	5.2
GUINOBATAN	8	5.2
HUMAYHUMAY	39	25.2
LA UNION	16	10.3
MAHAGBU	24	15.5
PANGPANG	23	14.8
SOOM	37	23.9
Subtotal (rainfed)	155	100
Subtotal (rainfed) w/o Guinobatan	147	
Total	315	
Total w/o Guinobatan	307	

Table 15: Mean transfer and punishment, by game and partner, in irrigated and rainfed areas.

VARIABLE	(1) Volumetric n=86	(2)[a] Area-based n=74	(3)=(1)&(2) All irrigated n=160	(4)[b] Rainfed n=147
Dictator Game				
Somebody in your Purok	34.19	35.41	34.75	28.78***
	(22.52)	(18.81)	(20.83)	(18.87)
Somebody in your Barangay	31.51	34.32	32.81	28.08**
	(21.17)	(21.33)	(21.23)	(17.39)
Somebody in your Municipal	27.21	26.76	27	23.95^{+}
	(20.90)	(19.10)	(20.03)	(16.90)
TSA member in your Barangay	32.67	35.48	33.96	
	(22.09)	(23.04)	(22.50) ***	
TSA member in diff. Barangay	26.74	30.14	28.30	
	(19.06)	(21.38)	(20.16)	
Ultimatum Game				
Somebody in your Purok	24.53	26.81	25.57	34.32***
	(16.57)	(15.18)	(15.94)	(19.47)
Somebody in your Barangay	24.19	28.51^{+}	26.19	34.55***
	(17.04)	(17.73)	(17.44)	(20.99)
Somebody in your Municipal	23.14	28.38*	25.56	34.33***
	(17.30)	(18.87)	(18.18)	(20.78)
TSA member in your Barangay	25.70	28.38	26.94	
	(16.42)	(17.12)	(16.75)	
TSA member in diff. Barangay	24	28.08^{+}	25.89	
	(17.13)	(17.92)	(17.56)	
Trust Game - Sender				
Somebody in your Purok	39.77	41.23	40.44	44.10
	(20.97)	(20.61)	(20.76)	(25.21)
Somebody in your Barangay	38.14	42.03	39.94	42.31
	(21.28)	(20.74)	(21.06)	(23.99)
Somebody in your Municipal	35.93	39.73	37.67	40.84
	(21.00)	(20.27)	(20.69)	(22.87)
TSA member in your Barangay	39.30	42.60	40.82	
	(18.39)	(19.15)	(18.76)	
TSA member in diff. Barangay	37.21	40.68	38.81	
	(21.18)	(22.19)	(21.65)	
Trust Game – Receive and Return				
Received amount	127.9	117.2	122.9	126.3
	(61.49)	(61.66)	(61.61)	(73.42)
Somebody in your Purok	51.86	41.67*	47.22	39.50**
	(38.15)	(29.55)	(34.77)	(26.84)
Somebody in your Barangay	48.49	41.10	45.09	39.50^{+}
	(39.00)	(27.67)	(34.36)	(25.22)
Somebody in your Municipal	45.53	40.14	43.08	35.18**
	(38.50)	(27.75)	(34.03)	(23.20)
TSA member in your Barangay	49.29	42.78	46.31	
	(38.35)	(28.69) *	(34.31)	
TSA member in diff. Barangay	49.76	40.28*	45.41	
	(41.95)	(26.69)	(35.98)	
Donation Game				
4 people in your Purok	42.67	39.46	41.19	37.38
	(27.03)	(20.33)	(24.14)	(22.79)
4 people in your Barangay	40.81	38.78	39.88	35.07*
	(26.49)	(20.13)	(23.71)	(21.57)
4 people in your Municipal	36.74	33.51	35.25	33.49

	(25.32)	(19.75)	(22.90)	(22.24)
4 people in your TSA	39.88	38.38	39.19	
	(23.94)	(20.61)	(22.40)	
Public Goods Game				
4 people in your Purok	45.35	44.59	45	44.17
	(26.29)	(20.55)	(23.74)	(26.30)
4 people in your Barangay	42.44	42.70	42.56	41.90
	(25.34)	(19.25)	(22.66)	(23.59)
4 people in your Municipal	41.40	40.96	41.19	39.52
	(25.17)	(18.72)	(22.37)	(23.59)
4 people in your TSA	46.94	45	46.04	
	(27.43)	(19.81)	(24.13)	
Public Goods Game w/ Punishment				
4 people in your Brgy (1^{st} round)	52.33	54.05	53.13	54.69
	(22.16)	(22.39)	(22.21)	(23.03)
Check result	0.593	0.378***	0.494	0.463
	(0.494)	(0.488)	(0.502)	(0.500)
Send unhappy message	0.512	0.284**	0.406	0.333
	(0.778)	(0.562)	(0.694)	(0.734)
4 people in your Barangay (2^{nd} round)	51.98	50.54	51.31	52.11
	(22.69)	(25.90)	(24.16)	(24.50)
Risk Game				
Betting amount	54.53	57.03	55.69	51.43^{+}
	(25.65)	(24.37)	(25.02)	(26.61)

Standard deviations in parentheses
a) t-test of mean difference from volumetric group (columns (1) and (2))
b) t-test of mean difference from all irrigated group (columns (3) and (4))
*** p<0.01, ** p<0.05, * p<0.1, + p<0.15

Table 16: Results of repeated public goods game in irrigated and rainfed areas.

VARIABLE	(1) Volumetric n=16	(2) Area-based n=14	(3)=(1)&(2) All irrigated n=30	(4) Rainfed n=32
Regular PGG				
1st round				
Investment	57.50	56.43	57	48.44*
	(21.76)	(20.61)	(20.87)	(15.05)
Result check	0.313	0.357	0.333	0.281
	(0.479)	(0.497)	(0.479)	(0.457)
Message	0.188	0.143	0.167	0.188
	(0.544)	(0.363)	(0.461)	(0.535)
2nd round				
Investment	61.88	58.57	60.33	54.06
	(22.28)	(22.82)	(22.20)	(17.20)
Result check	0.250	0.143	0.200	0.156
	(0.447)	(0.363)	(0.407)	(0.369)
Message	0.0625	0.143	0.100	0.156
	(0.250)	(0.363)	(0.305)	(0.574)
3rd round				
Investment	68.75	60	64.67	61.25
	(21.56)	(24.81)	(23.15)	(21.52)
Result check	0.500	0.357	0.433	0.406
	(0.516)	(0.497)	(0.504)	(0.499)
Message	0.313	0.214	0.267	0.406
	(0.479)	(0.426)	(0.450)	(0.665)
PGG w Punishment				
4th round				
Investment	73.13	60.71+	67.33	65.63
	(18.15)	(24.33)	(21.80)	(19.00)
Result check	0.500	0.286	0.400	0.375
	(0.516)	(0.469)	(0.498)	(0.492)
Message	0.188	0.286	0.233	0.219
	(0.403)	(0.611)	(0.504)	(0.420)
5th round				
Investment	74.38	67.14	71	68.44
	(27.80)	(23.67)	(25.78)	(19.86)
Result check	0.438	0.500	0.467	0.250*
	(0.512)	(0.519)	(0.507)	(0.440)
Message	0.0625	0.429**	0.233	0.250
	(0.250)	(0.646)	(0.504)	(0.568)
6th round				
Investment	68.13	58.57	63.67	68.44
	(34.10)	(34.16)	(33.88)	(24.77)
Result check	0.385	0.500	0.435	0.333
	(0.506)	(0.527)	(0.507)	(0.482)
Message	0.231	0.600	0.391	0.292
	(0.599)	(0.843)	(0.722)	(0.464)

Standard deviations in parentheses
a) t-test of mean difference from volumetric group (columns (1) and (2))
b) t-test of mean difference from all irrigated group (columns (3) and (4))
*** p<0.01, ** p<0.05, * p<0.1, + p<0.15

Table 17: Results of OLS regression analyses explaining attendance rate in TSA management meetings (including number of barangays).

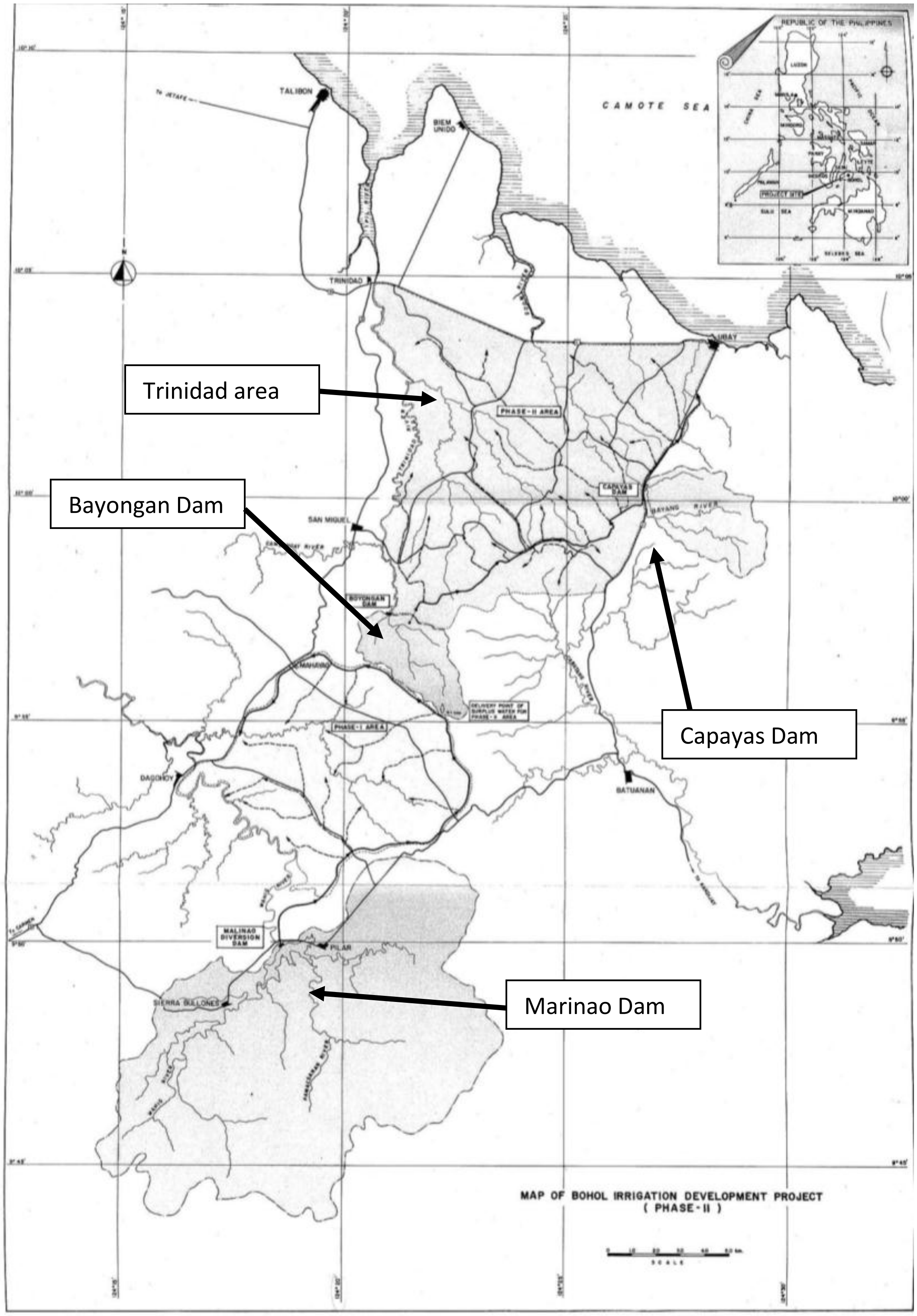
VARIABLE	(1) Meeting attended prop	(2) Meeting attended prop
TSA Homogeneity		
Within 1km brgy members prop	0.365**	0.498*
	(0.180)	(0.296)
* str_problem	-0.690	-1.202*
	(0.482)	(0.646)
*volumetric		-0.221
		(0.377)
*volumetric *str_problem		1.455
		(1.174)
Within 1km # of brgys	0.0242	-0.0495
	(0.134)	(0.211)
* str_problem	-0.296	-0.228
	(0.262)	(0.350)
*volumetric		0.135
		(0.284)
*volumetric *str_problem		-0.449
		(0.525)
Size		
TSA area	0.00326	0.00356
	(0.00643)	(0.00651)
* str_problem	0.0303	0.0343*
	(0.0184)	(0.0196)
TSA member	-0.00421	-0.00445
	(0.00530)	(0.00536)
* str_problem	-0.0212	-0.0194
	(0.0132)	(0.0134)
Water Tender		
No. of water tenders /ha	0.721*	0.789**
	(0.369)	(0.396)
* str_problem	-0.614	-0.509
	(0.617)	(0.659)
Tenancy		
CARP prop	0.0154	0.0364
	(0.152)	(0.160)
* str_problem	0.378	0.532
	(0.306)	(0.351)
Owner cultivator prop	-0.0553	-0.0389
	(0.184)	(0.187)
* str_problem	0.916**	1.075**
	(0.377)	(0.413)
Absentee landlord prop	0.272	0.282
	(0.190)	(0.192)
* str_problem	0.526	0.780
	(0.458)	(0.517)
Mortgaged-out land prop	0.435	0.470
	(0.308)	(0.317)
* str_problem	-0.241	0.214
	(1.648)	(1.728)
Pricing		
Volumetric	0.211***	0.234
	(0.0720)	(0.383)
* str_problem	-0.137	-0.792
	(0.146)	(0.975)
TSA Location		
Main-down	-0.215**	-0.217**
	(0.0867)	(0.0879)

* str_problem	0.386**	0.456***
	(0.156)	(0.169)
Main up/down-part down	-0.142*	-0.152*
	(0.0745)	(0.0767)
* str_problem	0.0420	0.0739
	(0.143)	(0.146)
Lateral-down	0.00851	0.0143
	(0.0750)	(0.0784)
* str_problem	-0.177	-0.220
	(0.162)	(0.170)
Infrastructure		
Str_problem	0.398	0.481
	(0.531)	(0.643)
Constant	0.198	0.152
	(0.258)	(0.368)
Observations	139	139
R-squared	0.277	0.289

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

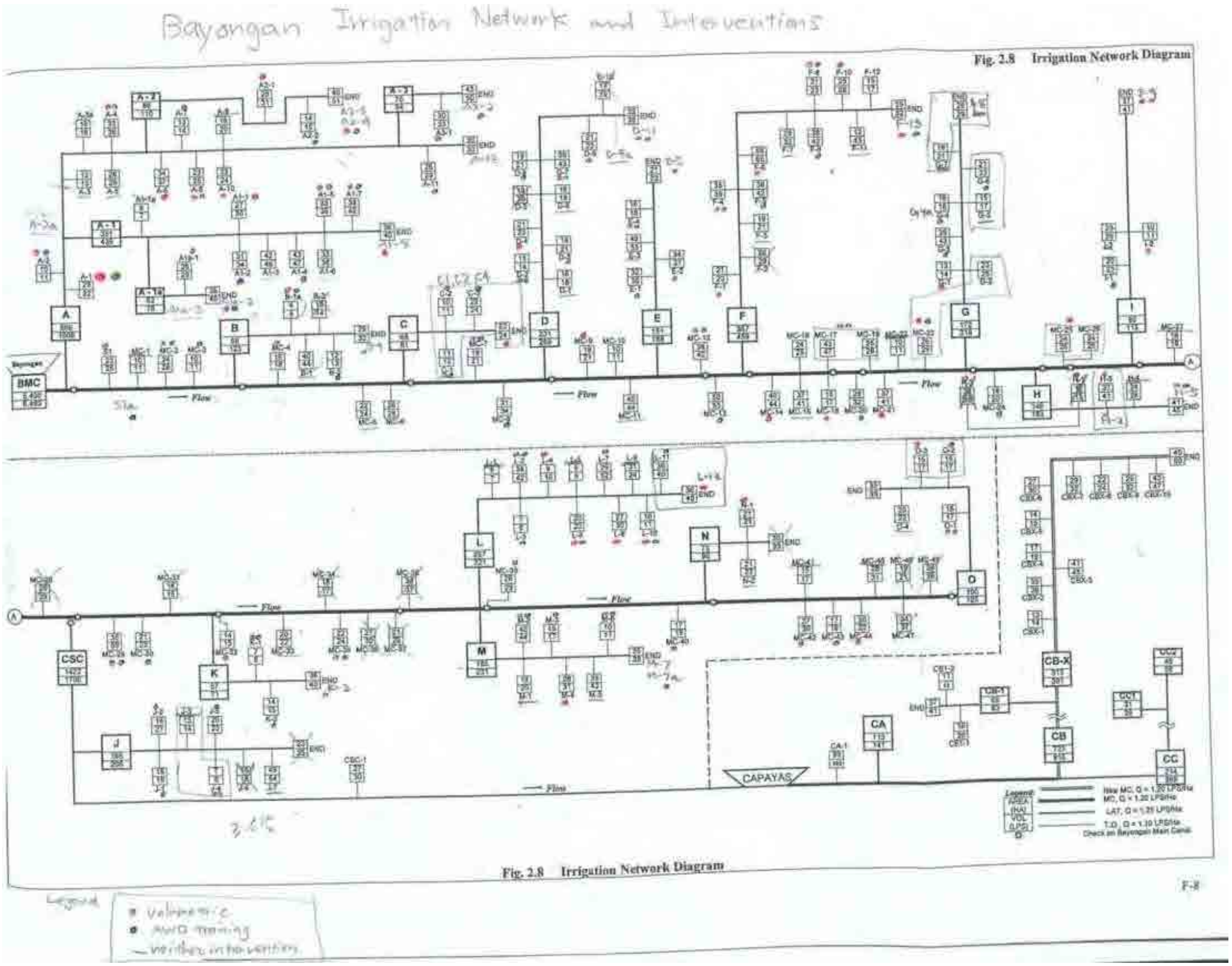
Figure 1. Location of the Bohol Irrigation System.

Figure 2. Location of the Bayongan Irrigation System.



Source: JICA (1985)

Figure 3. The irrigation network of the Bayongan system.



Source: NIA (2007)

Figure 4. Administrative structure of NIA's irrigation system.

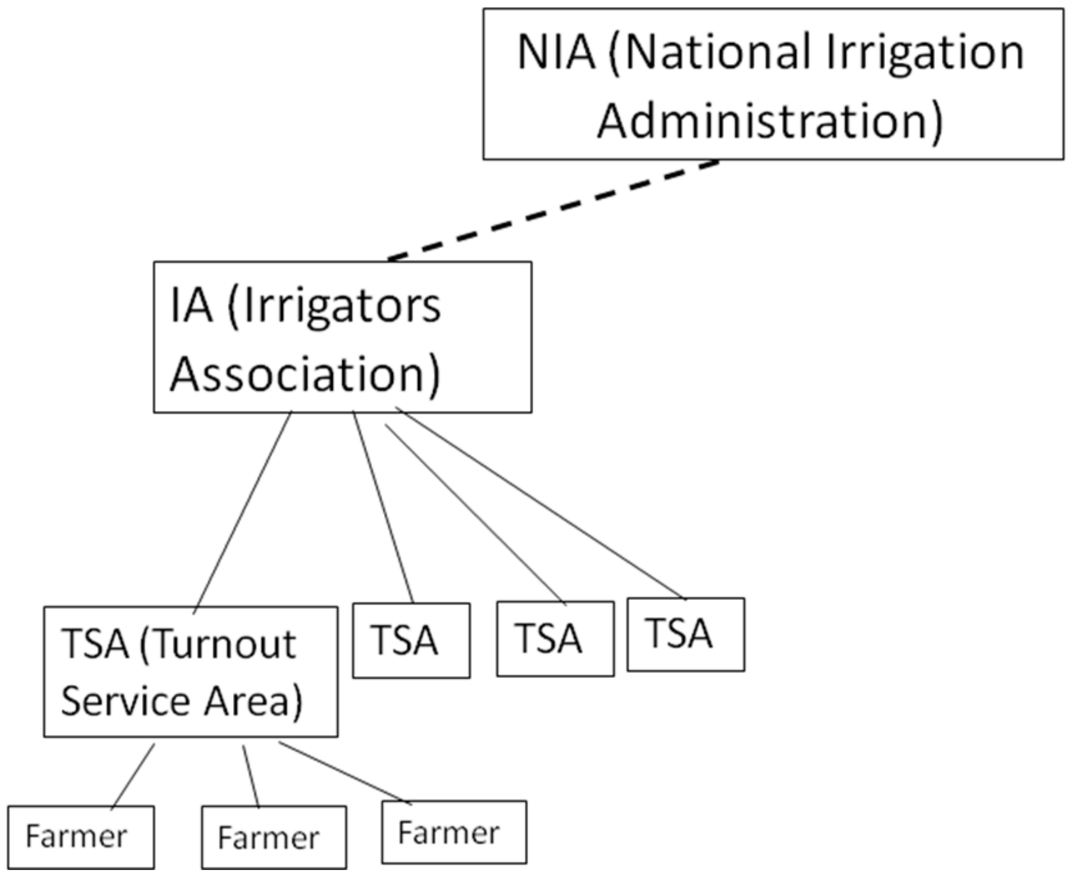
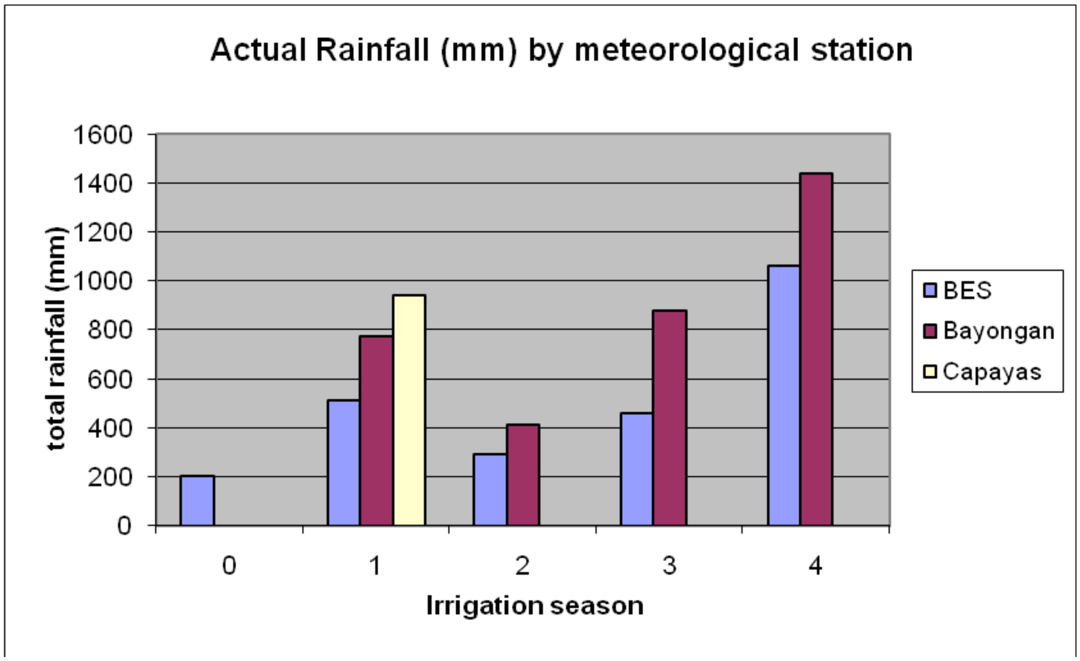
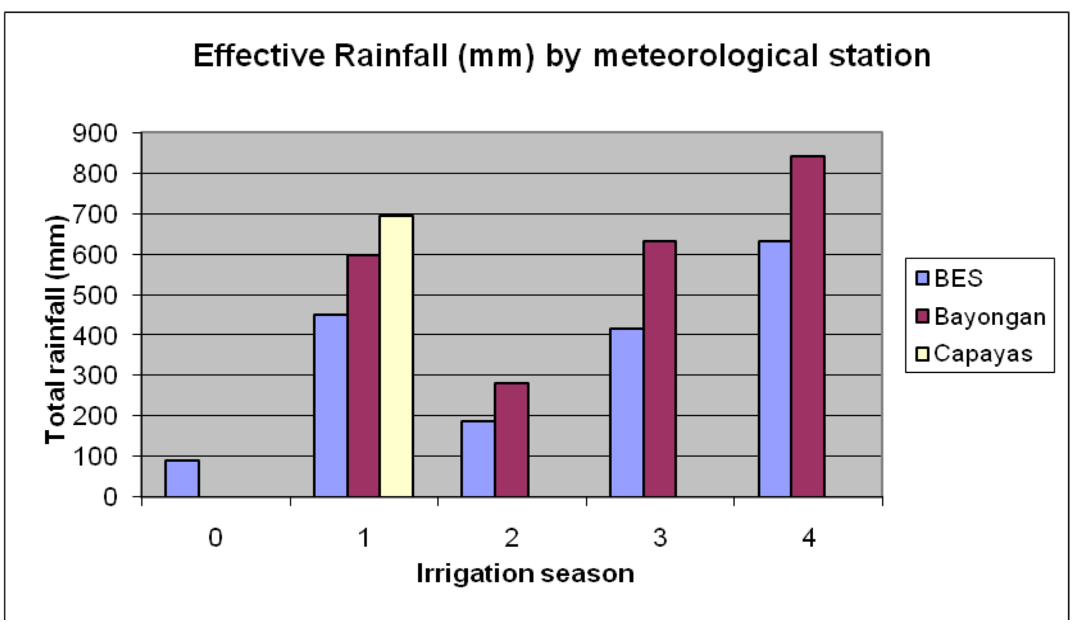


Figure 5. Rainfall in the project area, by season.

Panel A: Actual rainfall

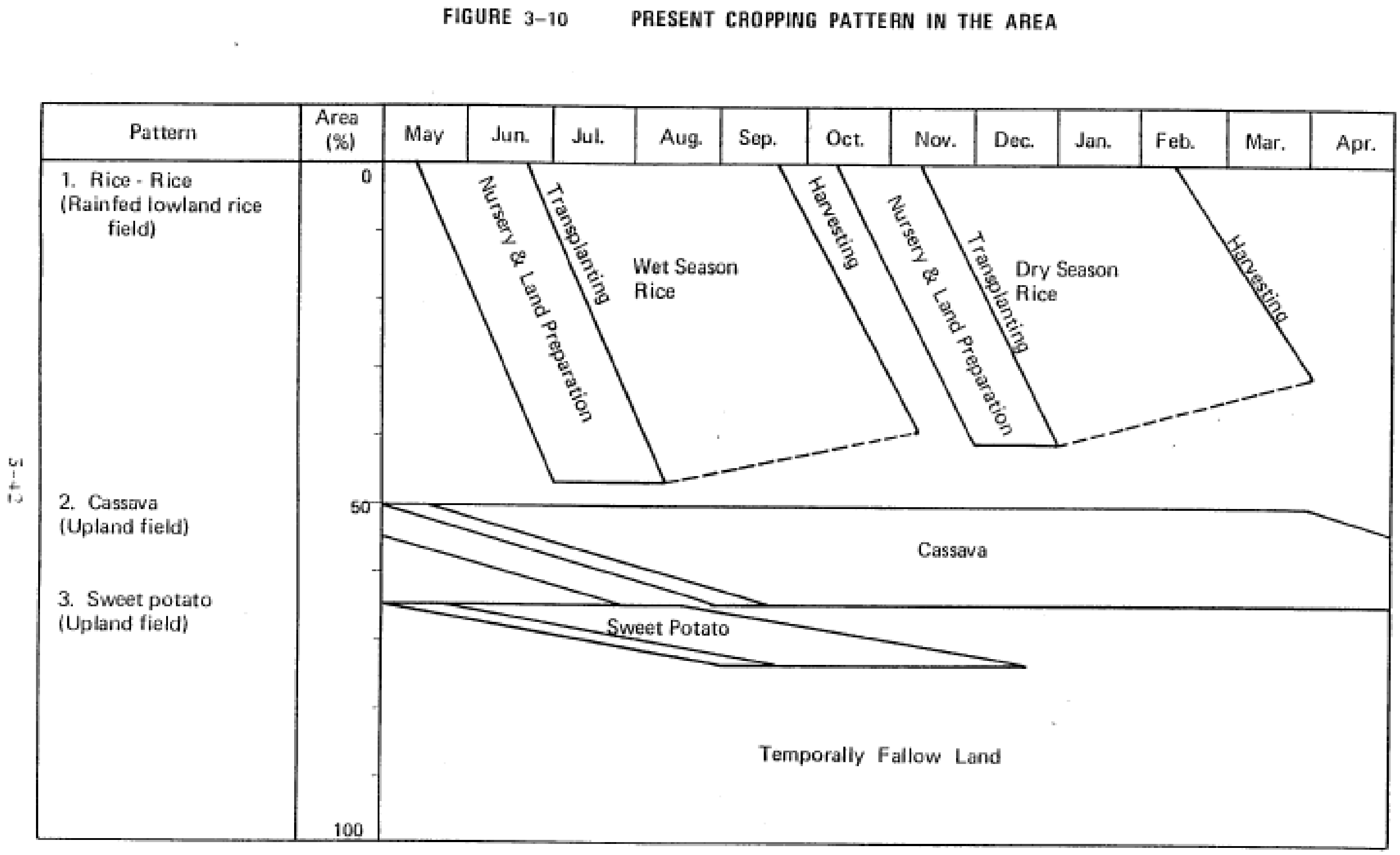


Panel B: Effective rainfall



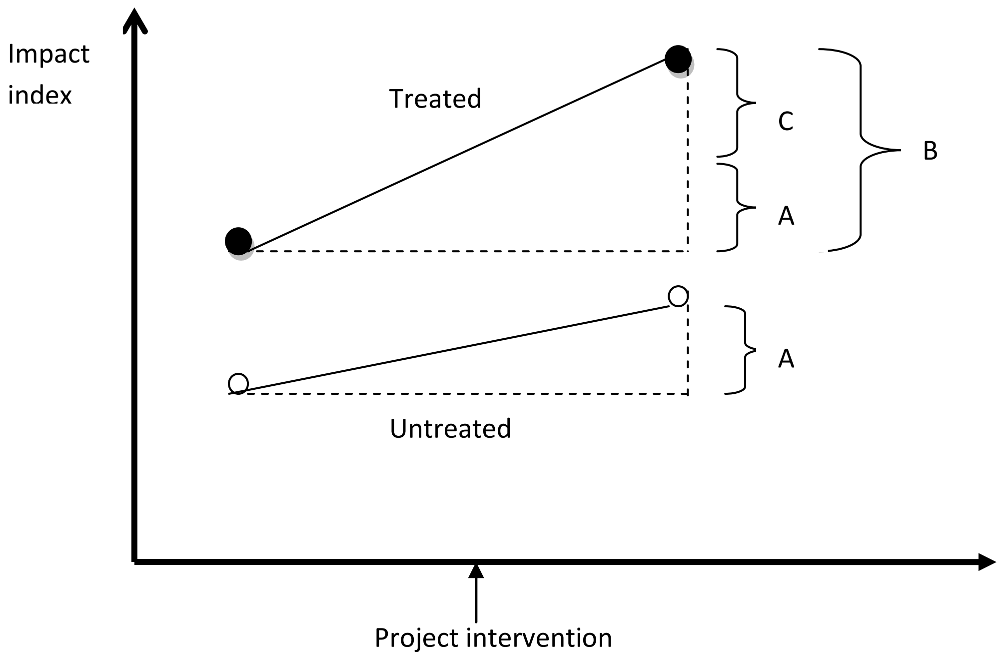
Note: An irrigation season is defined as the period from dam opening day to closing day.

Figure 6. Crop calendar before the irrigation project.

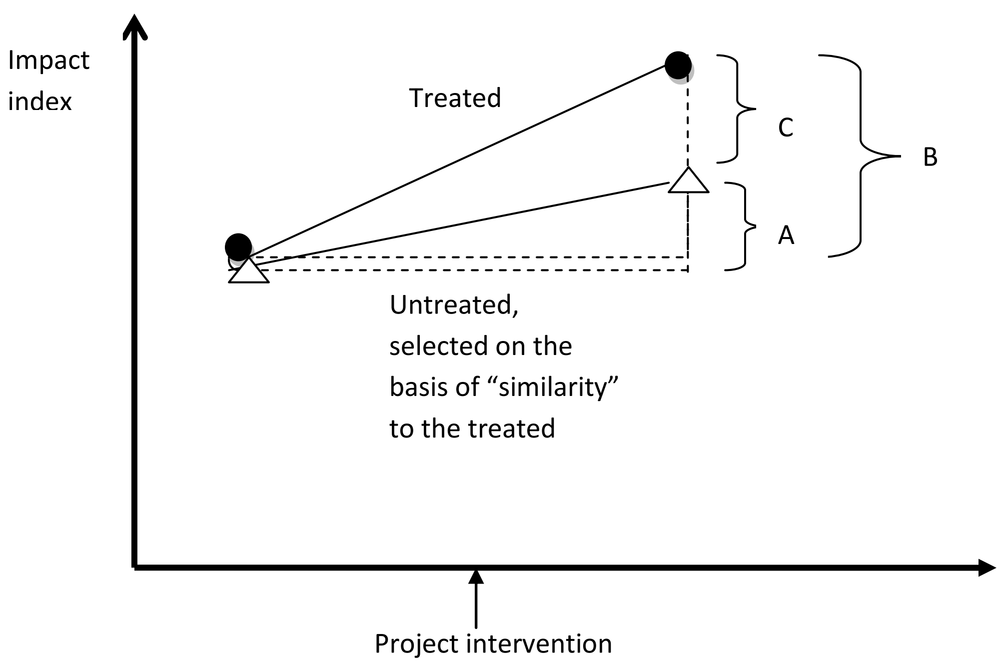


Source: JICA (1985)

Figure 7. Schematic diagram of the impact assessment process.



(i) Schematic diagram of impact assessment using the DID approach



(ii) Schematic diagram of impact assessment with counter factual untreated

Figure 8. Location of survey plots in the study area.

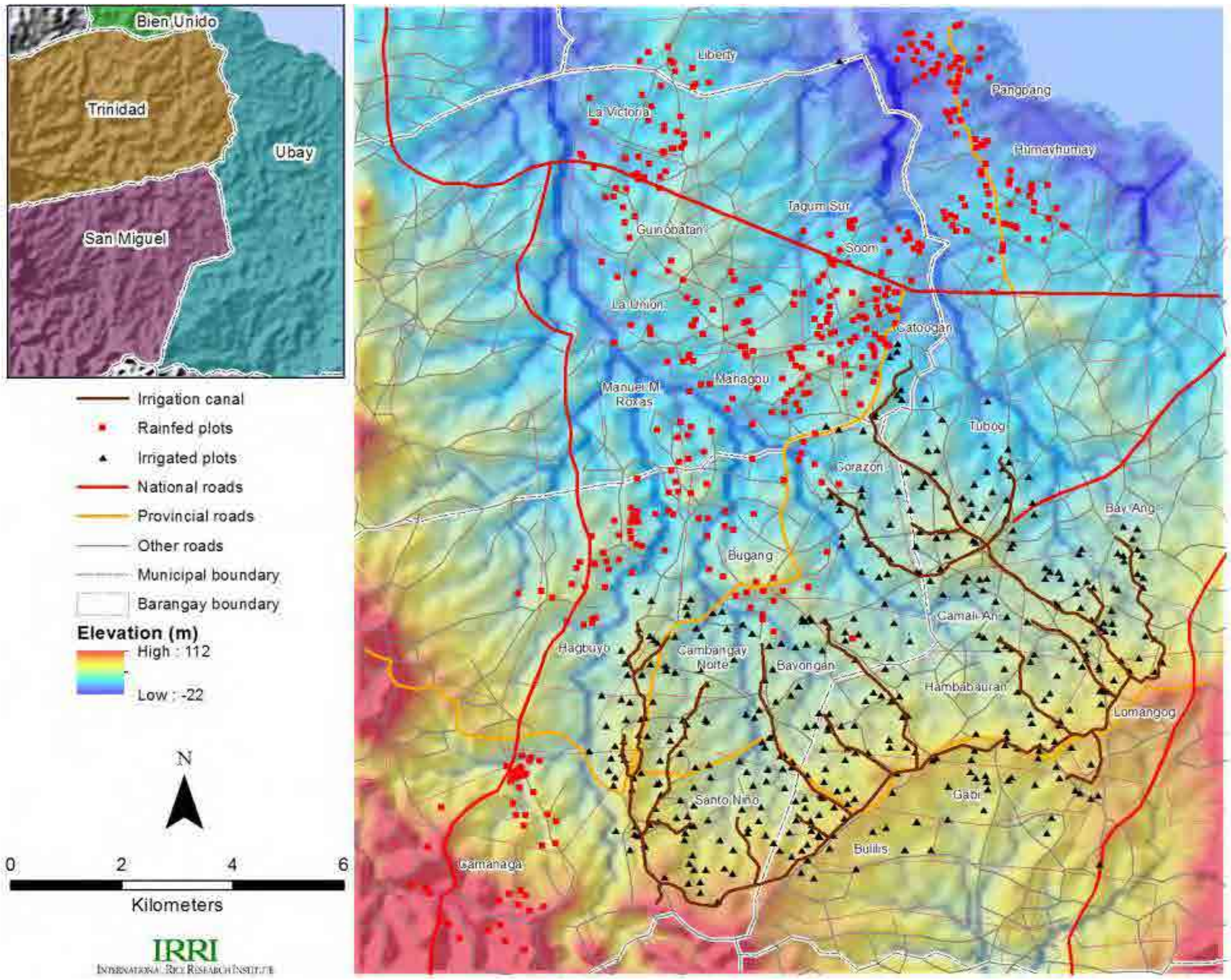


Figure 9. Design of randomized field experiments on volumetric pricing and AWD training.

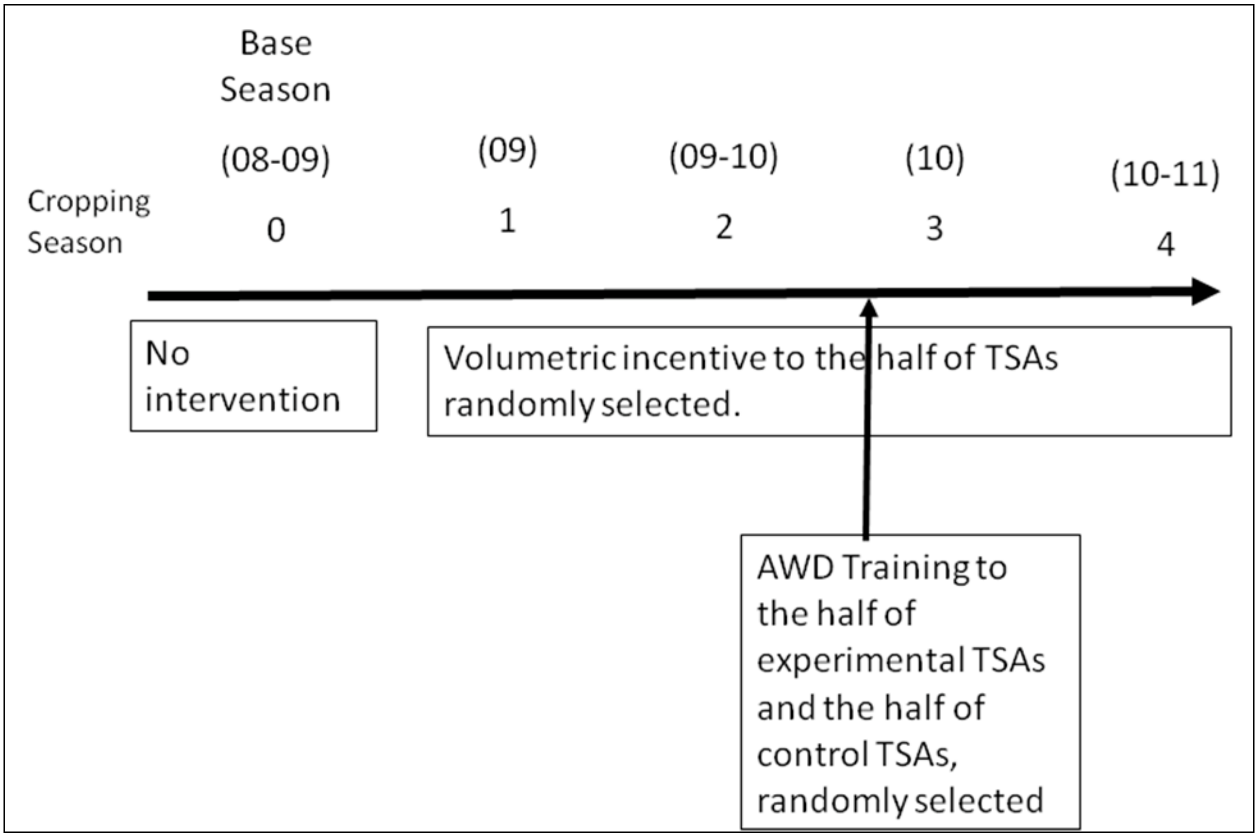


Figure 10. Irrigation schedule under alternate wetting and drying (AWD).

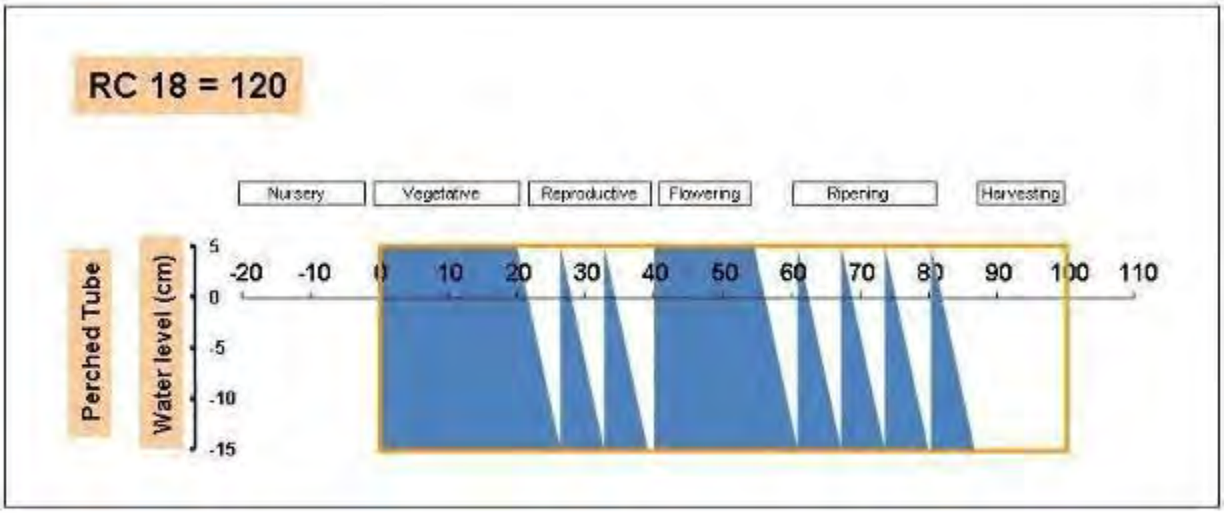


Figure 11. Hypothesis on the impact of volumetric pricing and AWD training over time under constant rainfall assumption.

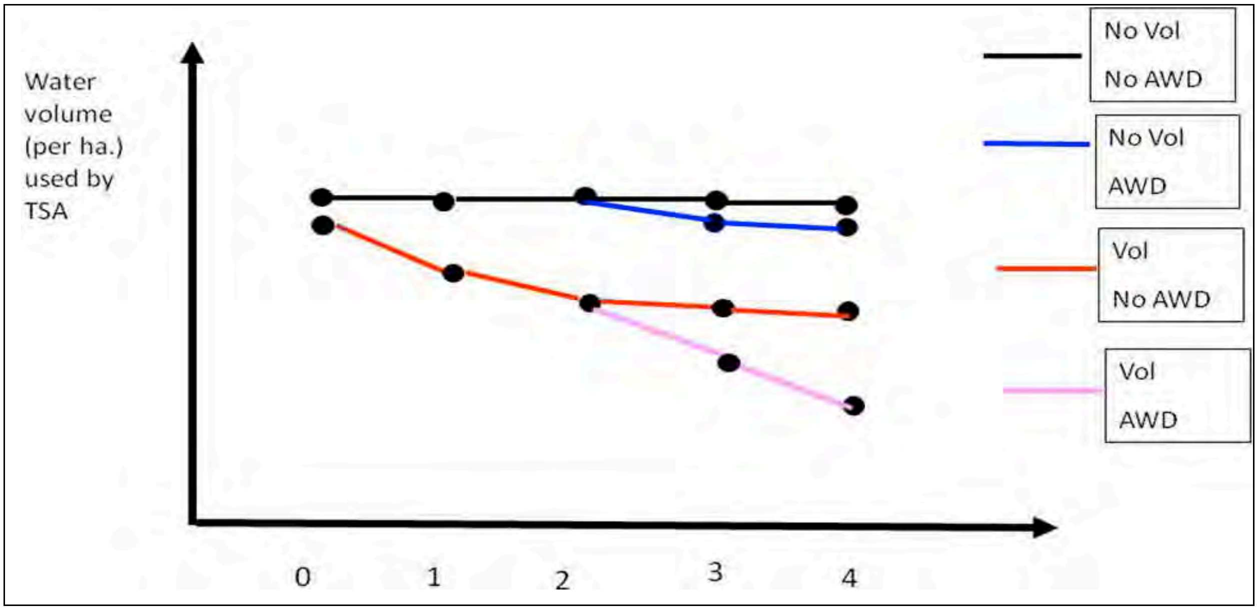


Figure 12. Sample plots and irrigable areas identified by the JICA feasibility study.

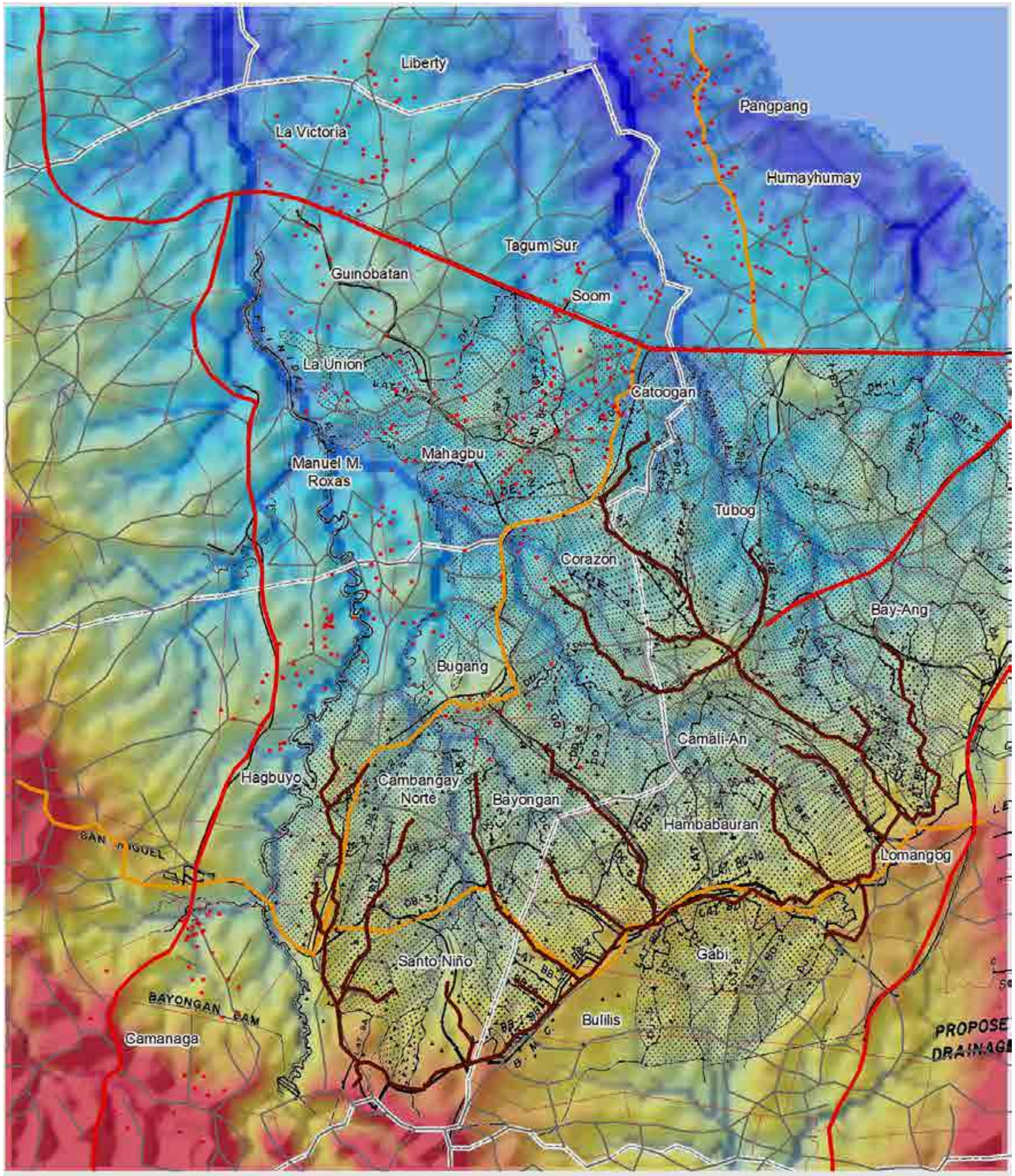


Figure 13. Soil map around Bohol Province, Philippines.

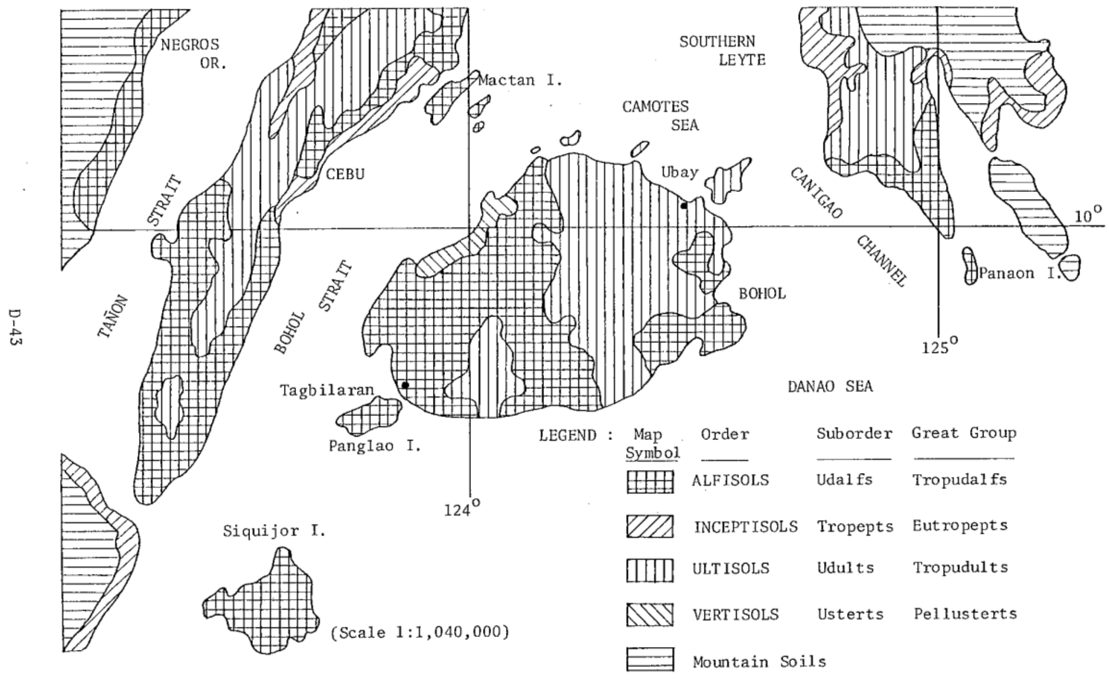
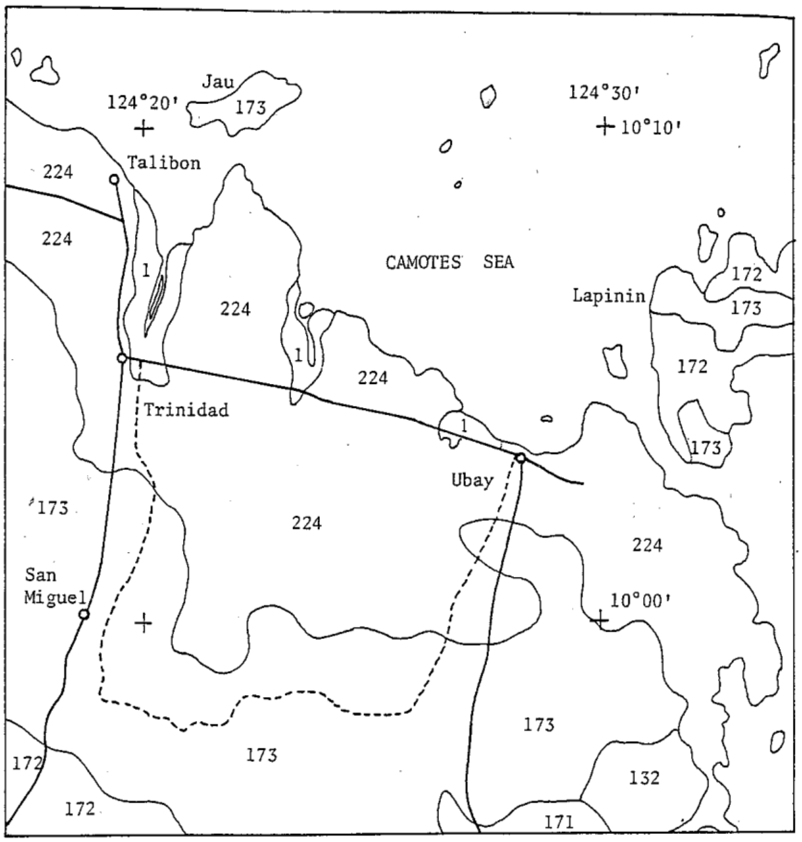


FIGURE D 5 - 1 SOIL MAP OF THE PHILIPPINES AROUND BOHOL PROVINCE (1972)

Source: JICA (1985)

Figure 14. Soil types around the project area (cited from a soil survey report of Bohol Province).



Scale 1:200,000

------ Project Boundary

LEGEND:

Soil Type No.	Name of Soil Type	Suborder	Order
1	Hydrosol	Aquents	ENTISOLS
132	Faraon Clay		
171	Rough stony land		
172	Ubay clay loam	Udults	ULTISOLS
173	Ubay clay	Udults	ULTISOLS
224	Ubay Sandy Loam	Udults	ULTISOLS

FIGURE D 5 - 2. SOIL TYPES AROUND THE PROJECT AREA CITED FROM THE SOIL SURVEY REPORT OF BOHOL PROVINCE (1947)

D-44

Figure 15. General soil map of the project area.

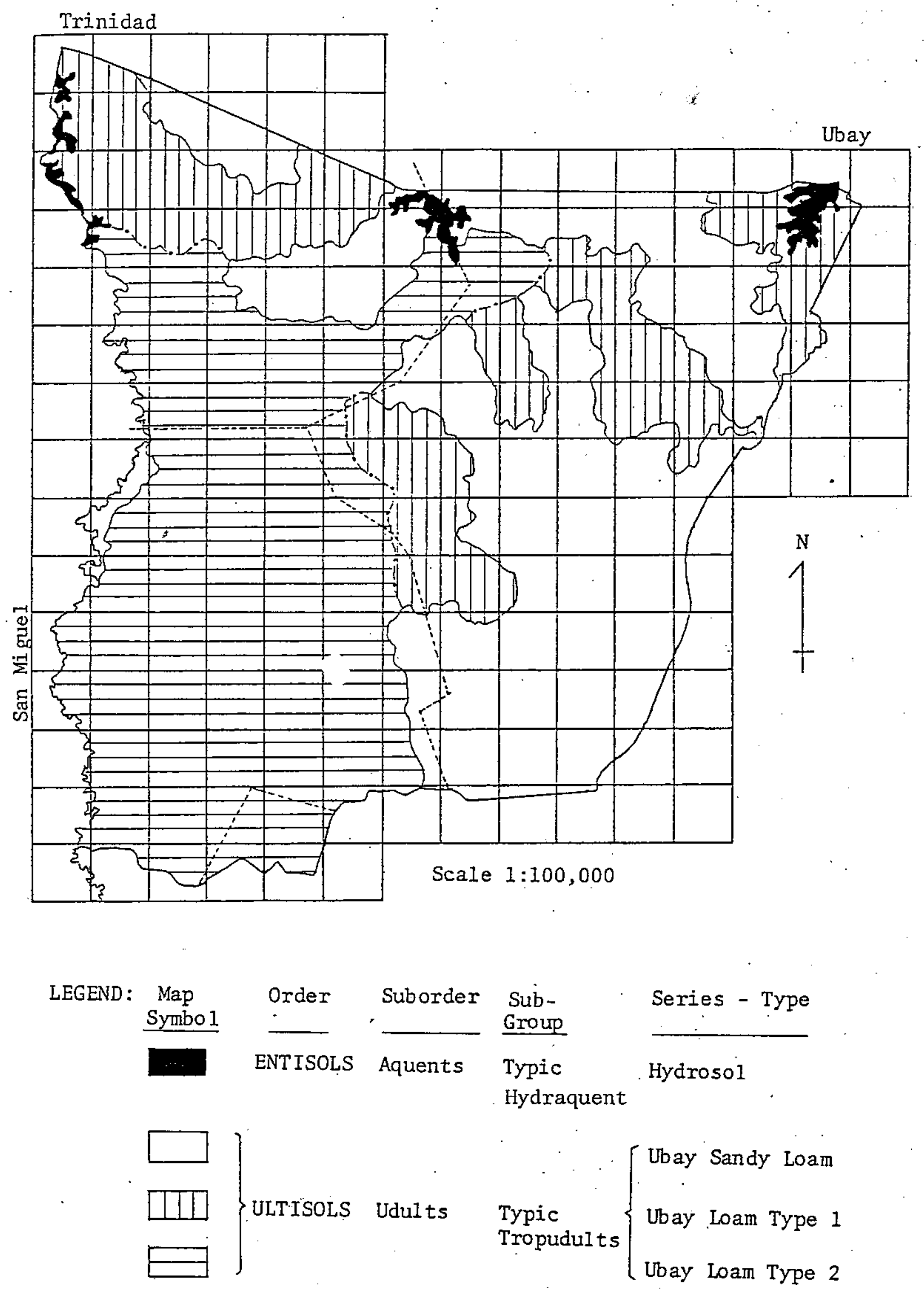
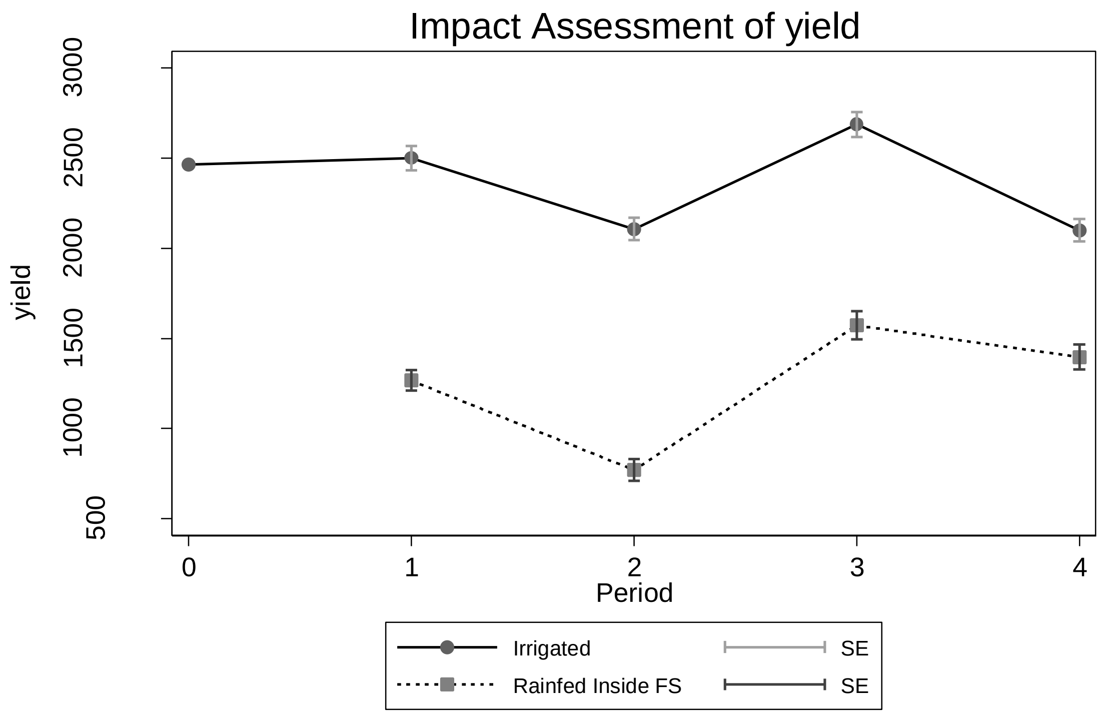


FIGURE D 5 - 6 GENERAL SOIL MAP OF THE PROJECT AREA

D-51

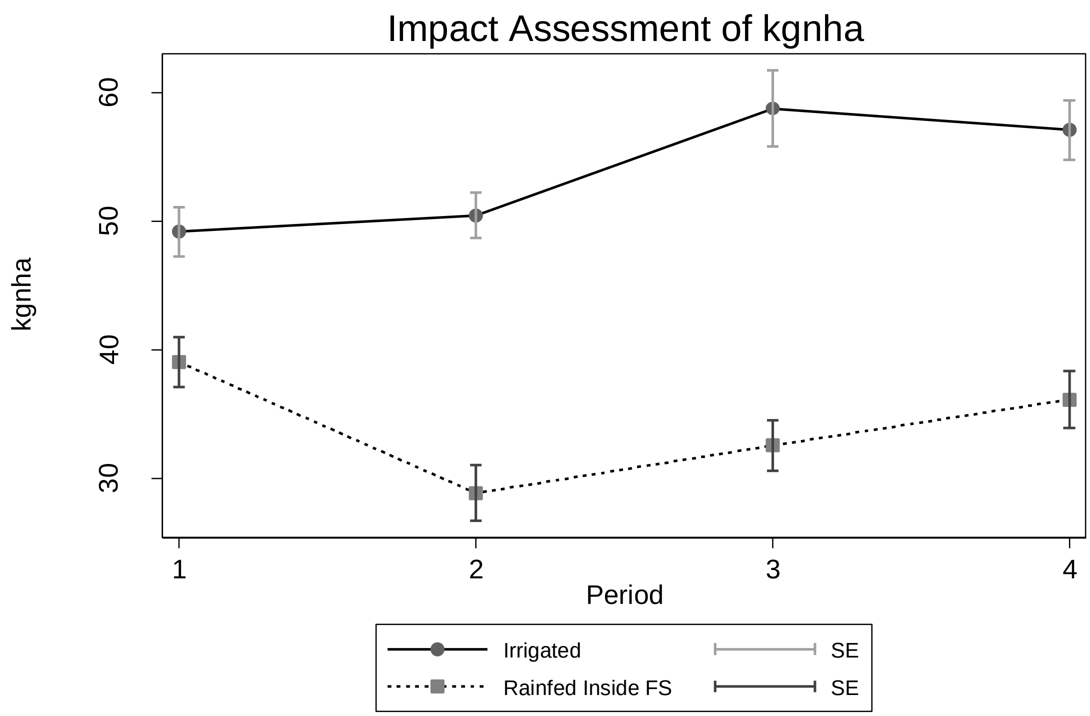
Source: JICA (1985)

Figure 16. Rice yield in irrigated and rainfed areas over the survey period.



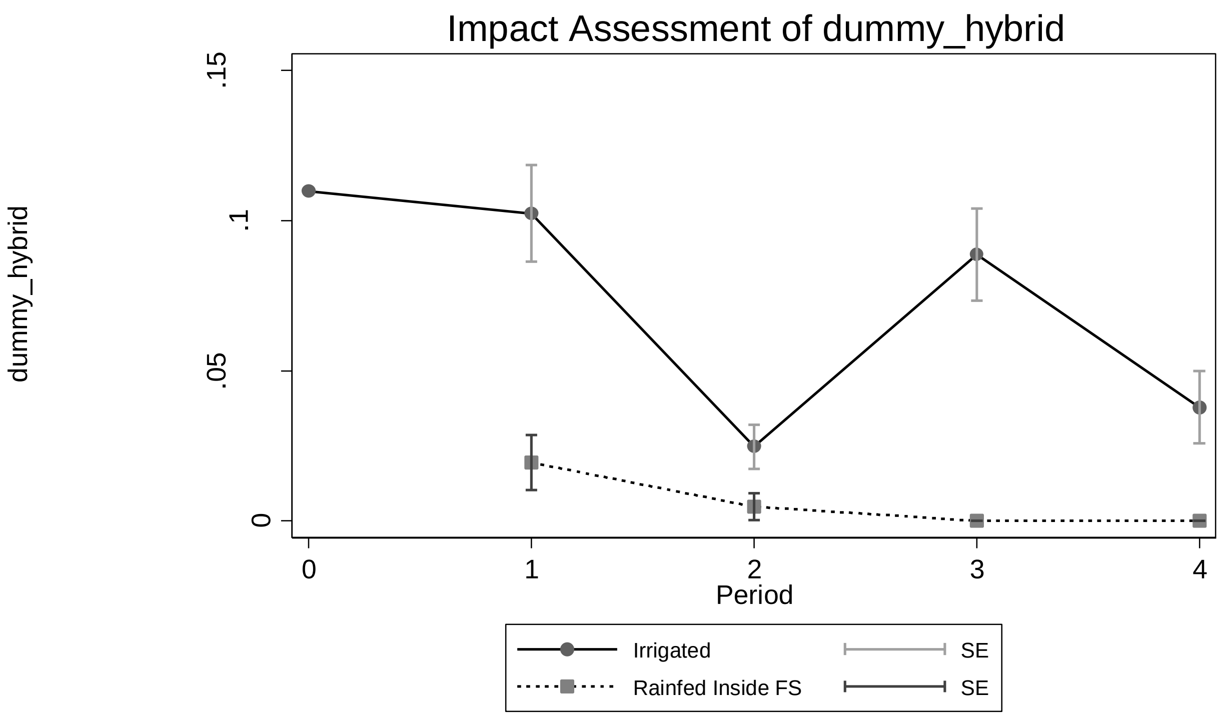
Period	Irrigated	Rainfed inside FS	Difference	95% interval		p value
1	2500	1266	1234	1062	1406	0.00
2	2108	770	1337	1169	1505	0.00
3	2679	1572	1107	900	1313	0.00
4	2103	1397	706	521	891	0.00

Figure 17. Nitrogen application in irrigated and rainfed fields over the survey period.



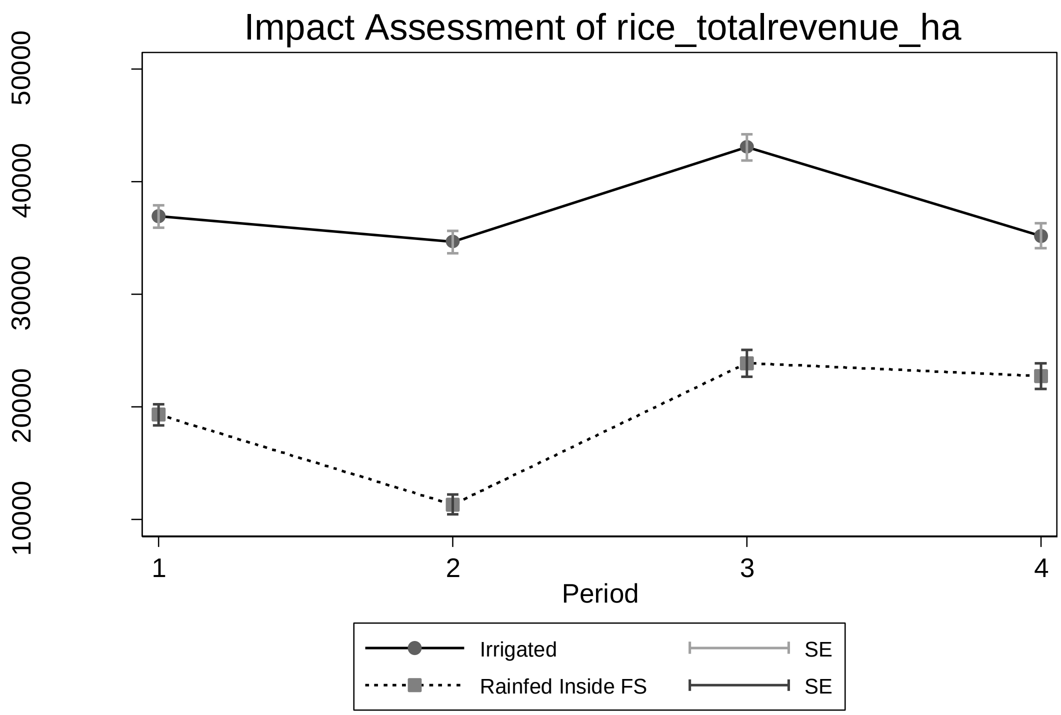
Period	Irrigated	Rainfed inside FS	Difference	95% interval		p value
1	49	39	10	5	15	0.00
2	50	29	21	16	27	0.00
3	59	33	26	19	33	0.00
4	57	36	21	15	27	0.00

Figure 18. Use of hybrid rice varieties in irrigated and rainfed fields over the survey period.



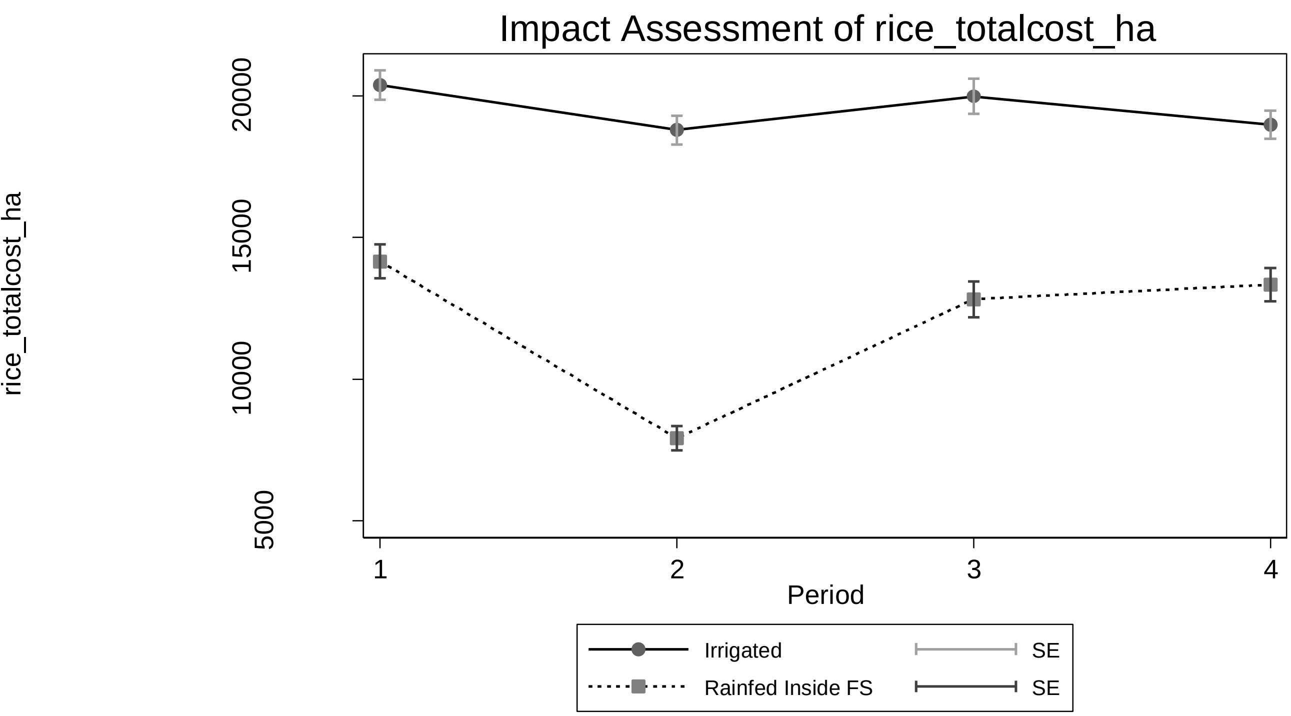
Period	Irrigated	Rainfed inside FS	Difference	95% interval		p value
1	0.102	0.019	0.083	0.047	0.120	0.00
2	0.025	0.005	0.020	0.003	0.037	0.02
3	0.089	0.000	0.089	0.059	0.119	0.00
4	0.038	0.000	0.038	0.015	0.061	0.00

Figure 19. Rice production revenue in irrigated and rainfed fields over the survey period.



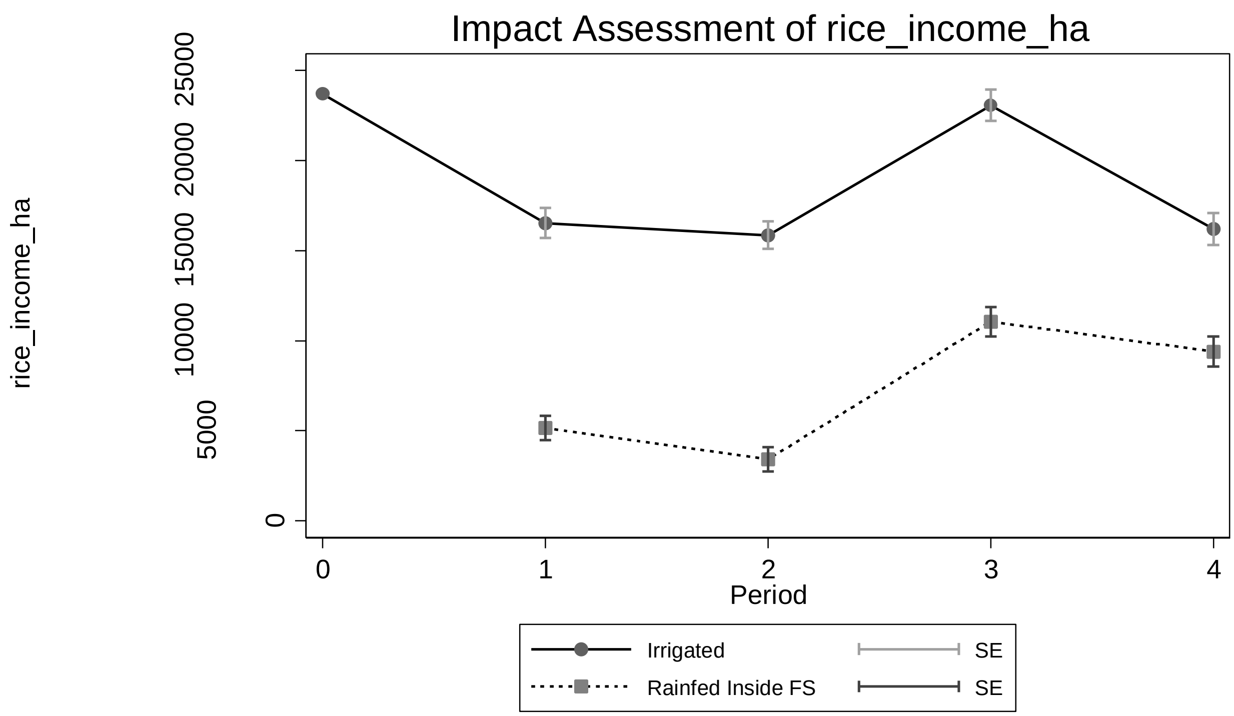
Period	Irrigated	Rainfed inside FS	Difference	95% interval		p value
1	36915	19313	17601	14898	20304	0.00
2	34640	11330	23310	20691	25929	0.00
3	43053	23892	19161	15873	22448	0.00
4	35184	22739	12444	9301	15588	0.00

Figure 20. Rice production cost in irrigated and rainfed fields over the survey period.



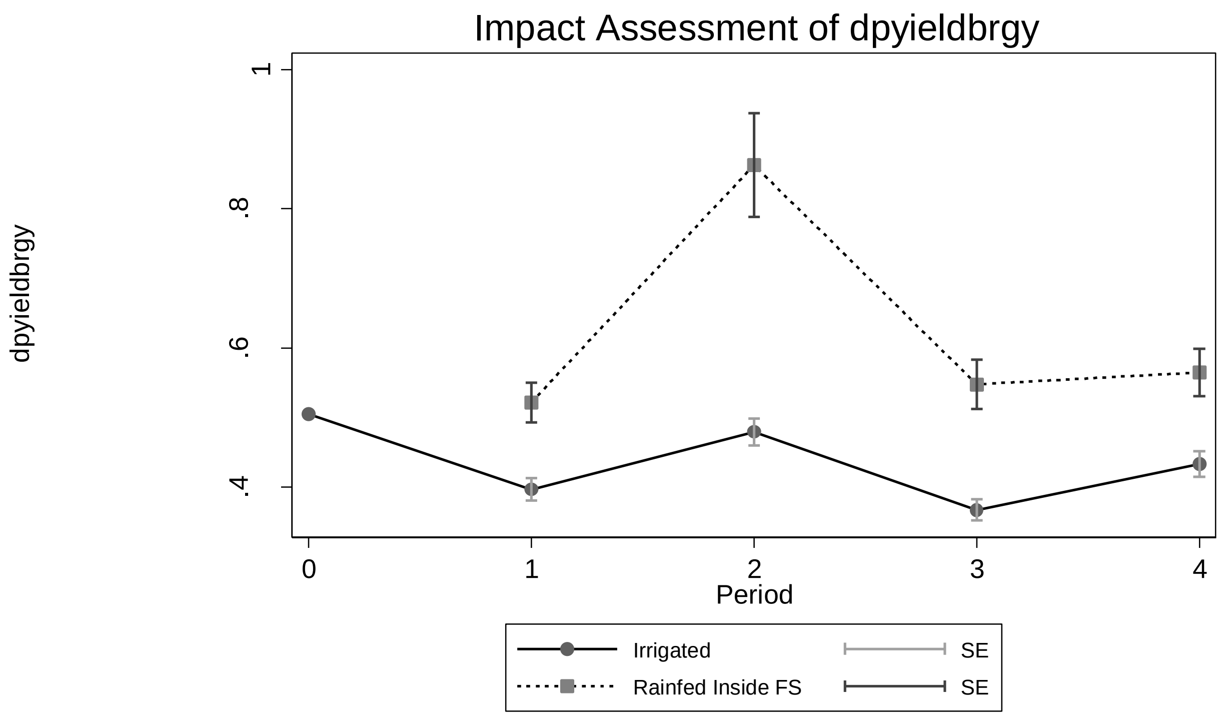
Period	Irrigated	Rainfed inside FS	Difference	95% interval		p value
1	20382	14162	6219	4659	7780	0.00
2	18795	7917	10877	9568	12187	0.00
3	19989	12829	7160	5428	8892	0.00
4	18978	13342	5636	4130	7142	0.00

Figure 21. Rice income of irrigated and rainfed farms over the survey period.



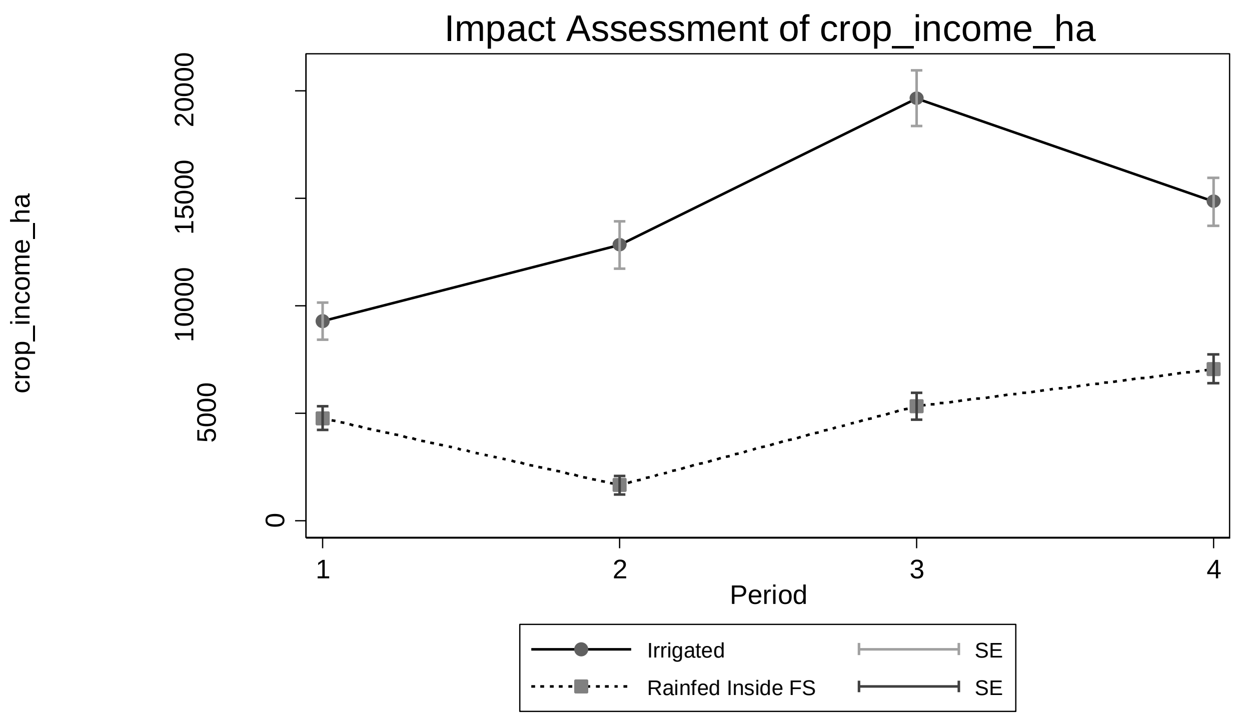
Period	Irrigated	Rainfed inside FS	Difference	95% interval		p value
1	16533	5151	11381	9291	13471	0.00
2	15845	3412	12432	10423	14441	0.00
3	23064	11063	12000	9667	14334	0.00
4	16205	9396	6808	4387	9229	0.00

Figure 22. Proportional variation of yield from barangay average yield in irrigated and rainfed fields over the survey period.



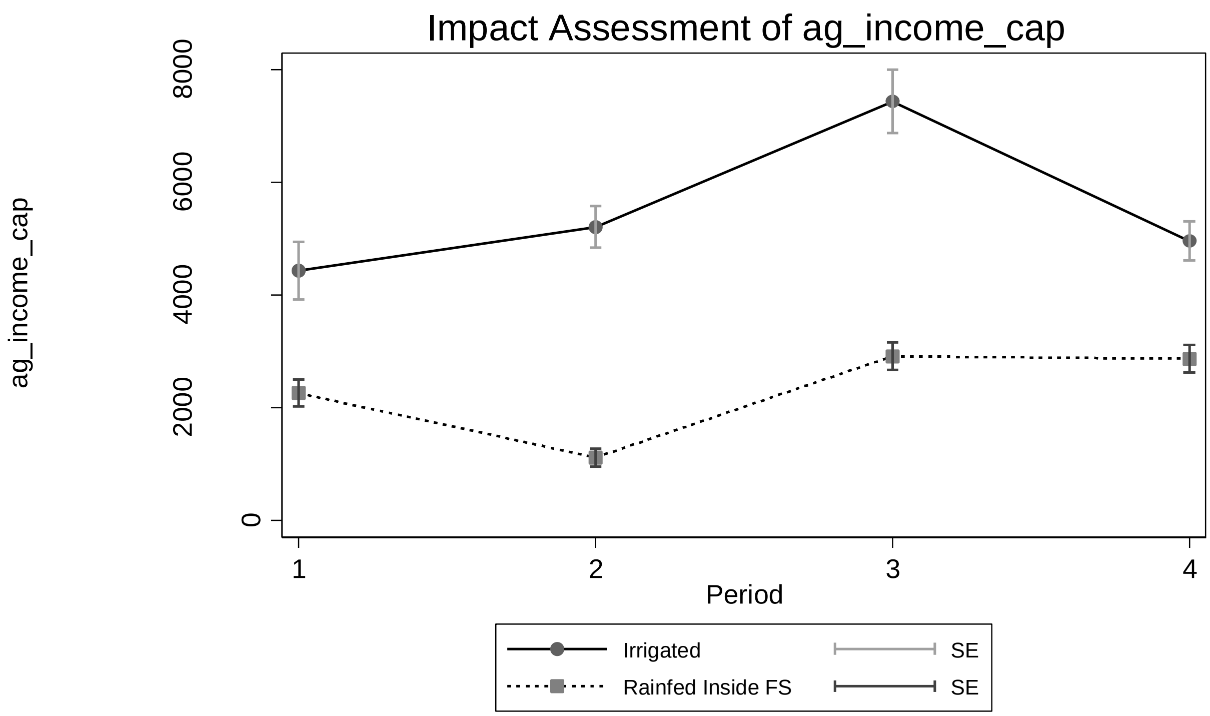
Period	Irrigated	Rainfed inside FS	Difference	95% interval		p value
1	0.397	0.522	-0.125	-0.189	-0.061	0.00
2	0.480	0.863	-0.383	-0.535	-0.231	0.00
3	0.367	0.548	-0.180	-0.256	-0.105	0.00
4	0.433	0.565	-0.131	-0.208	-0.055	0.00

Figure 23. Crop income in irrigated and rainfed fields over the survey period.



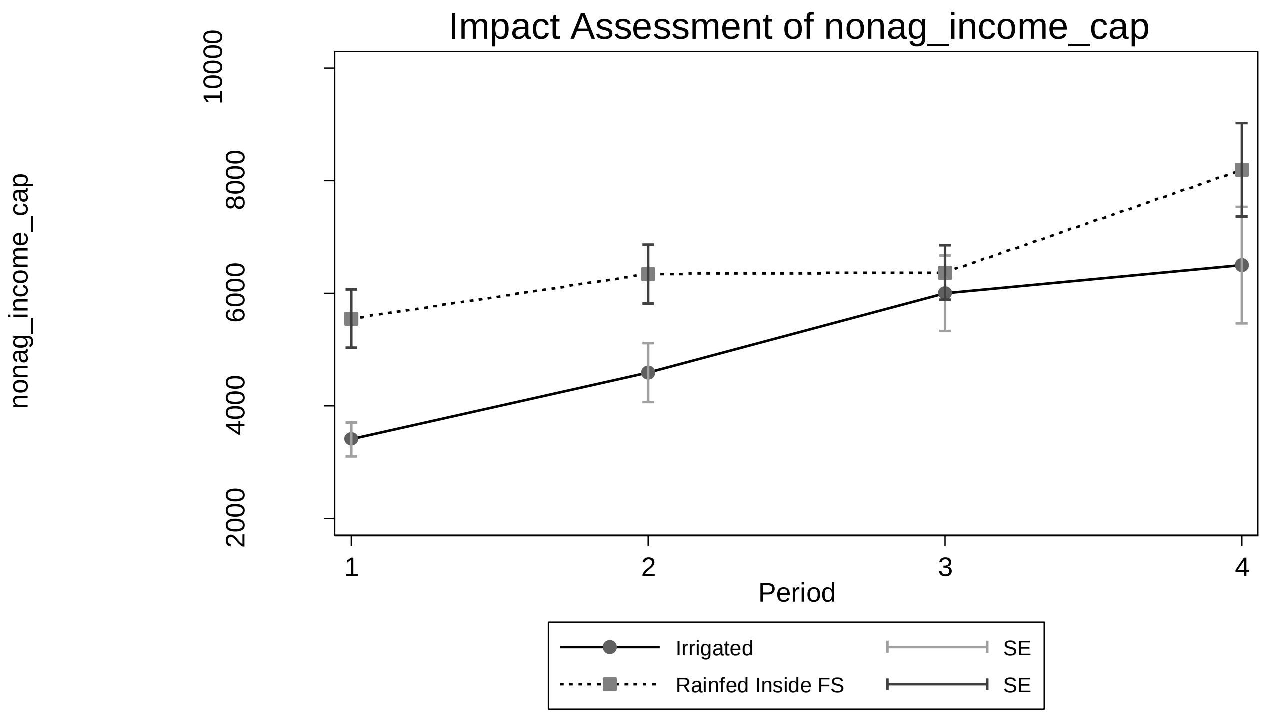
Period	Irrigated	Rainfed inside FS	Difference	95% interval		p value
1	9288	4773	4514	2484	6544	0.00
2	12813	1662	11150	8832	13468	0.00
3	19642	5329	14312	11496	17129	0.00
4	14832	7054	7777	5225	10329	0.00

Figure 24. Agricultural income per capita in irrigated and rainfed farms over the survey period.



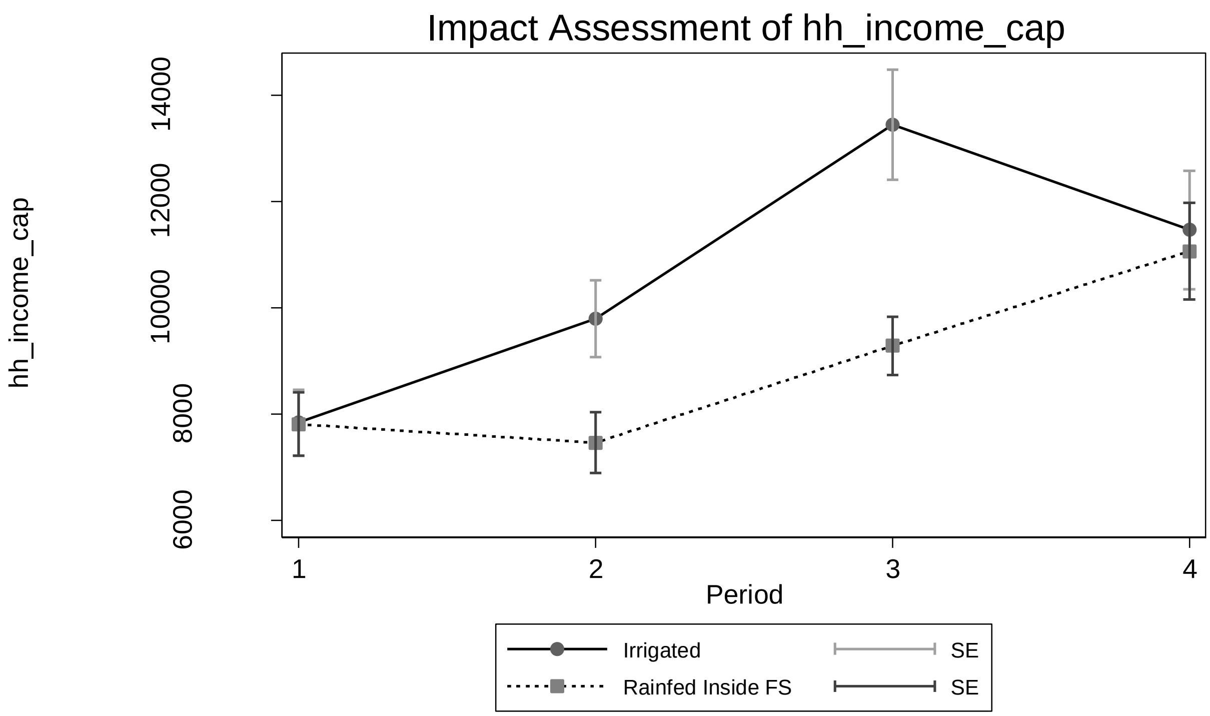
Period	Irrigated	Rainfed inside FS	Difference	95% interval		p value
1	4429	2260	2169	1057	3280	0.00
2	5208	1118	4089	3300	4878	0.00
3	7437	2914	4522	3320	5724	0.00
4	4959	2870	2089	1256	2921	0.00

Figure 25. Non-agricultural income per capita in irrigated and rainfed farms over the survey period.



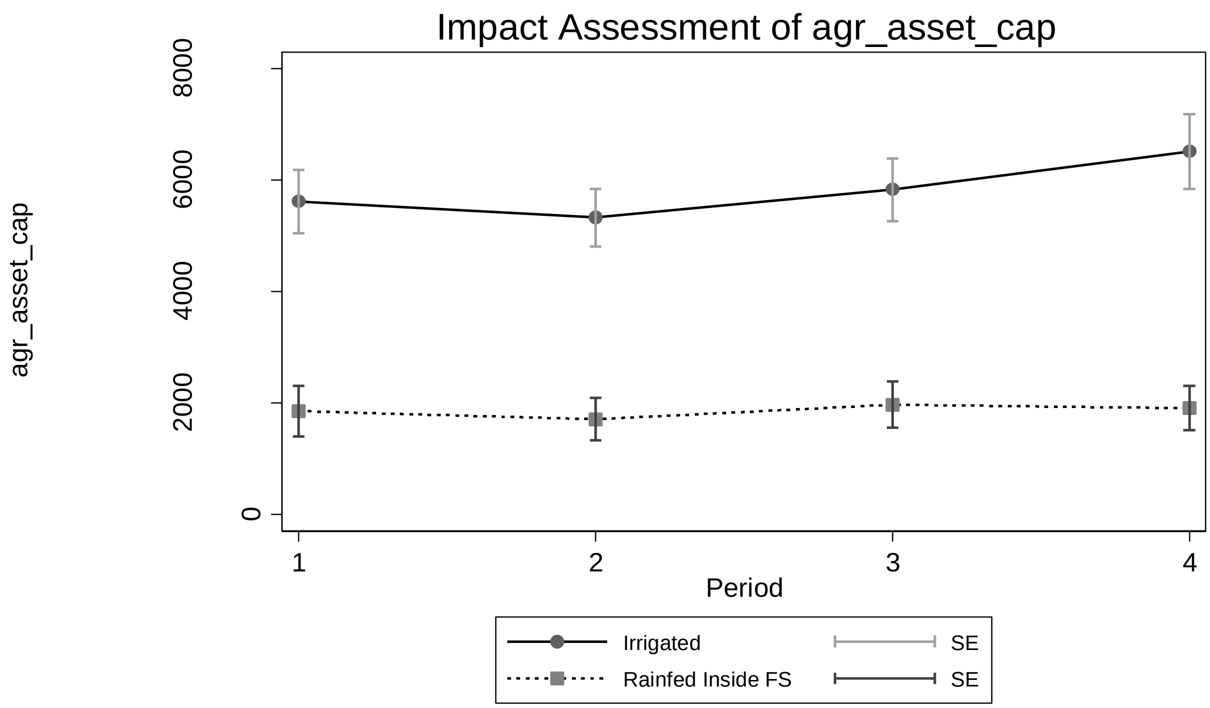
Period	Irrigated	Rainfed inside FS	Difference	95% interval		p value
1	3411	5551	-2140	-3318	-962	0.00
2	4587	6344	-1756	-3202	-311	0.02
3	6001	6369	-367	-1995	1259	0.66
4	6502	8191	-1688	-4289	912	0.20

Figure 26. Household income per capita in irrigated and rainfed farms over the survey period.



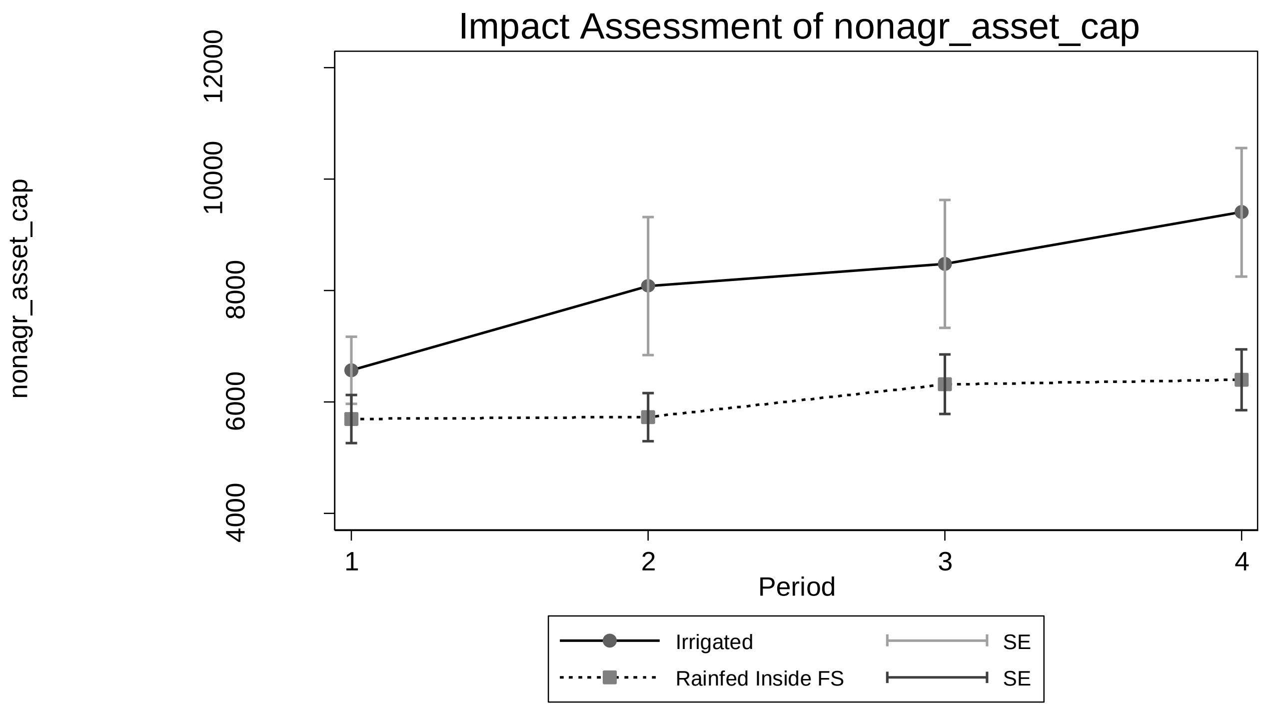
Period	Irrigated	Rainfed inside FS	Difference	95% interval		p value
1	7841	7812	28	-1664	1722	0.97
2	9796	7463	2332	524	4141	0.01
3	13439	9284	4155	1848	6461	0.00
4	11462	11062	400	-2421	3221	0.78

Figure 27. Agricultural asset value (excluding livestock) per capita in irrigated and rainfed farms over the survey period.



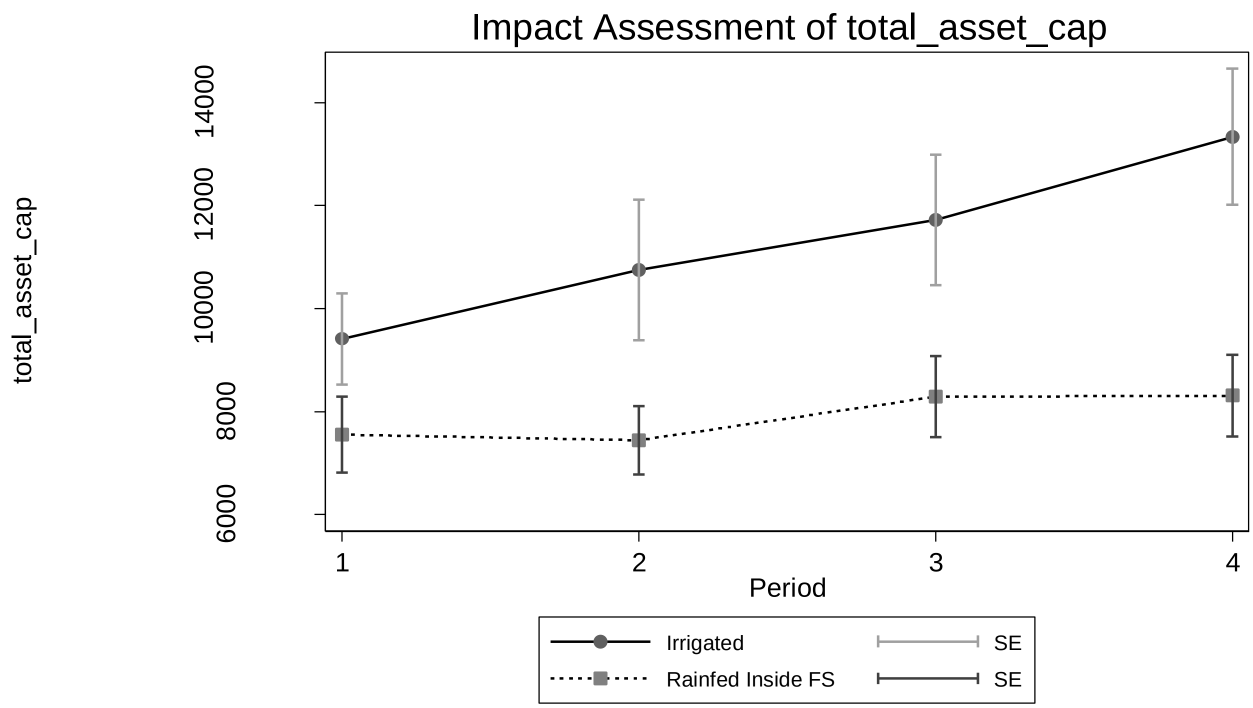
Period	Irrigated	Rainfed inside FS	Difference	95% interval		p value
1	5615	1856	3759	2331	5187	0.00
2	5327	1710	3617	2362	4871	0.00
3	5827	1971	3856	2491	5220	0.00
4	6509	1909	4599	3071	6128	0.00

Figure 28. Non-agricultural asset value per capita in irrigated and rainfed farms over the survey period.



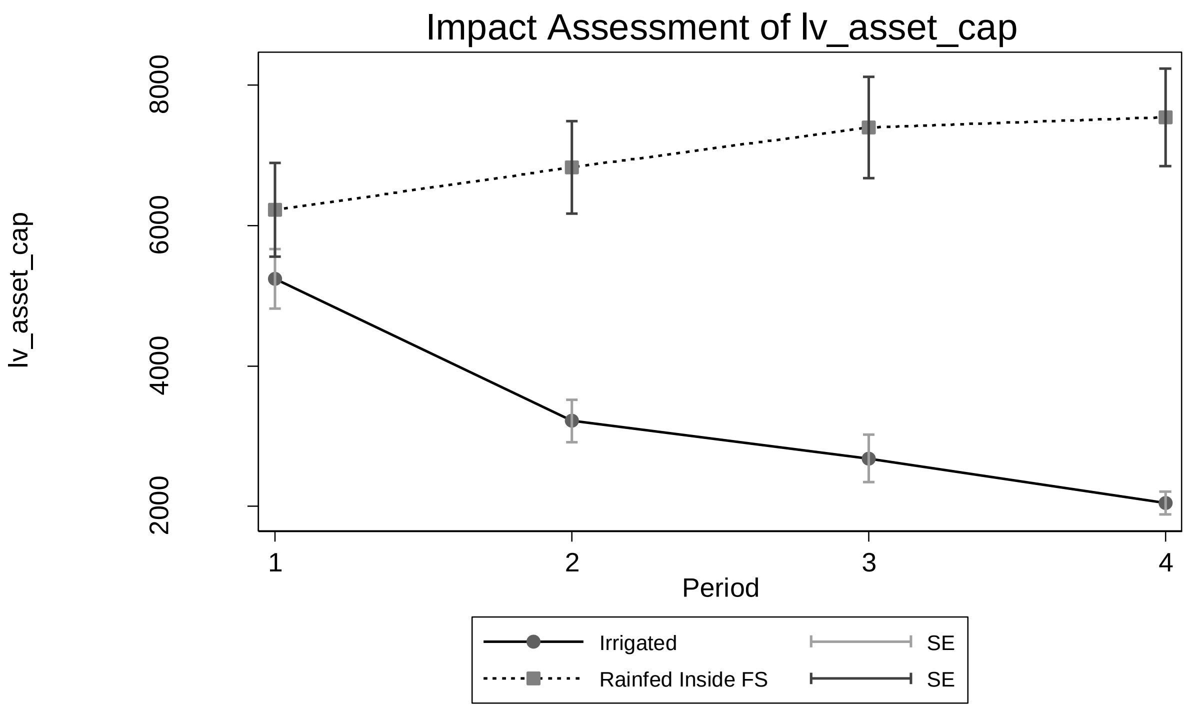
Period	Irrigated	Rainfed inside FS	Difference	95% interval		p value
1	6570	5697	873	-577	2324	0.24
2	8079	5732	2346	-223	4917	0.07
3	8476	6317	2158	-324	4641	0.09
4	9405	6400	3004	503	5506	0.02

Figure 29. Total asset value (excluding livestock) per capita in irrigated and rainfed farms over the survey period.



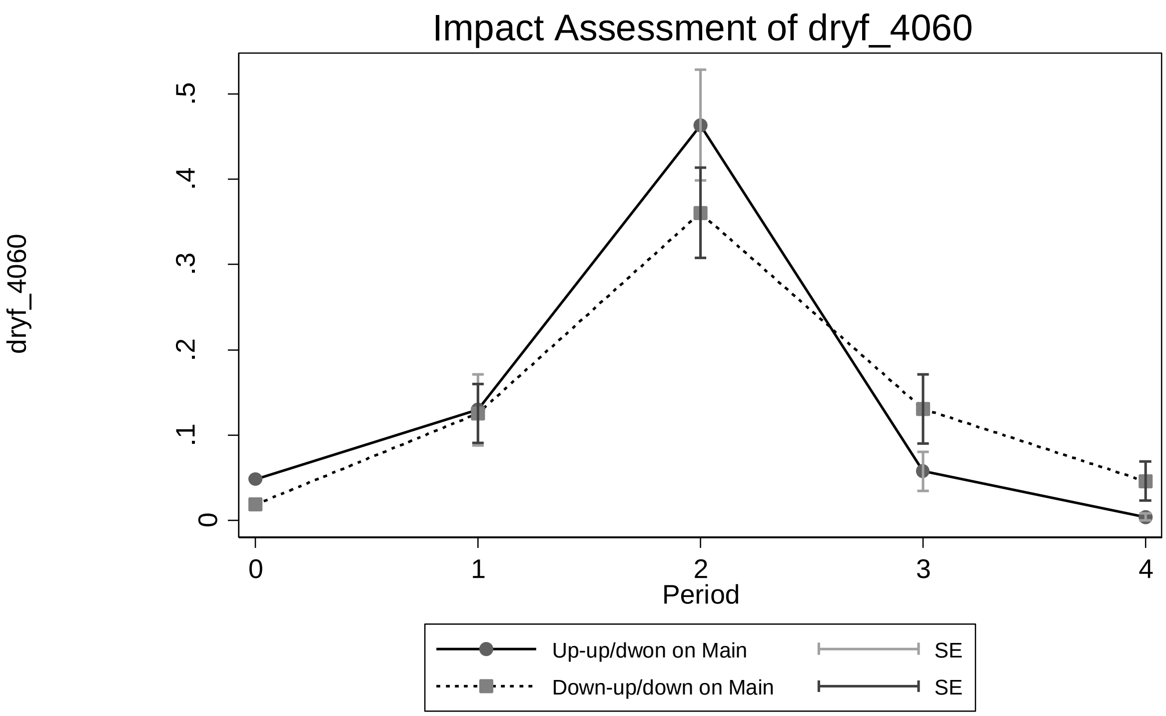
Period	Irrigated	Rainfed inside FS	Difference	95% interval		p value
1	9411	7554	1857	-401	415	0.11
2	10751	7443	3308	340	6277	0.03
3	11723	8289	3434	511	6358	0.02
4	13339	8310	5028	2006	8050	0.00

Figure 30. Livestock asset value per capita in irrigated and rainfed farms over the survey period.



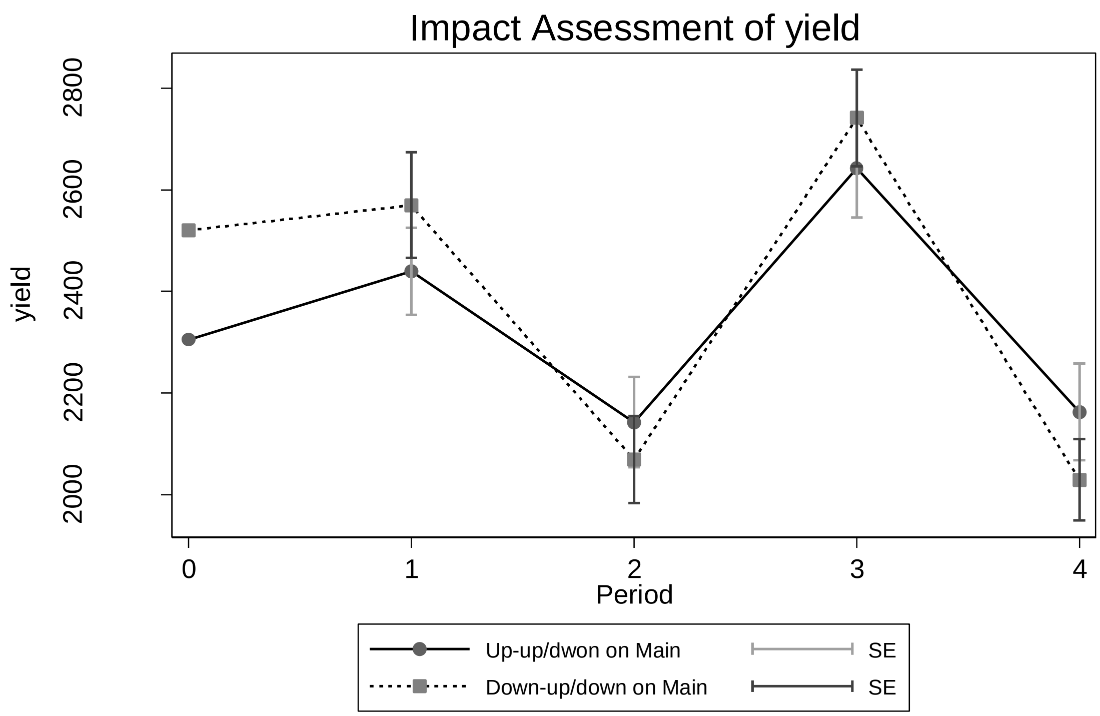
Period	Irrigated	Rainfed inside FS	Difference	95% interval		p value
1	5239	6224	-985	-2534	564	0.21
2	3217	6830	-3613	-5038	-2188	0.00
3	2682	7398	-4717	-6281	-3153	0.00
4	2048	7545	-5497	-6896	-4099	0.00

Figure 31. Water stress, by location along the up- or downstream section of the main canal over the survey period.



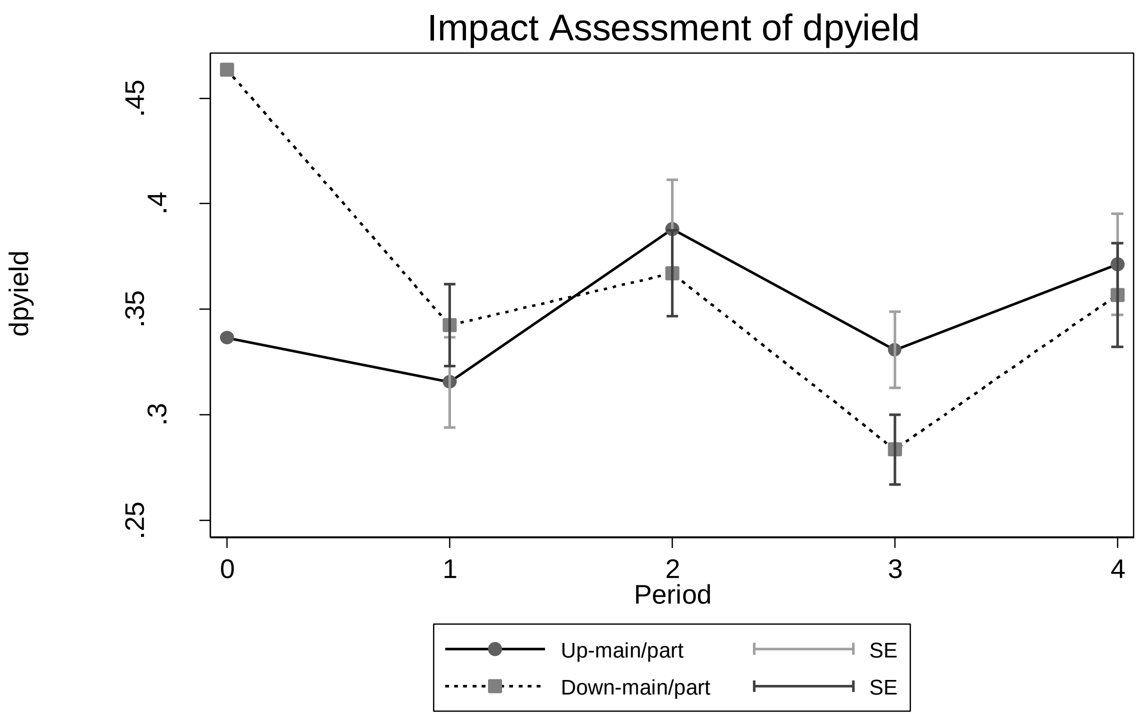
Period	Up-up/ down on main	Down-up/ down on main	Difference	95% interval		p value
1	0.13	0.13	0.004	-0.101	0.110	0.94
2	0.46	0.36	0.10	-0.06	0.27	0.23
3	0.06	0.13	-0.07	-0.16	0.02	0.12
4	0.004	0.046	-0.041	-0.087	0.004	0.07

Figure 32. Rice yield, by location along the up- or downstream section of the main canal over the survey period.



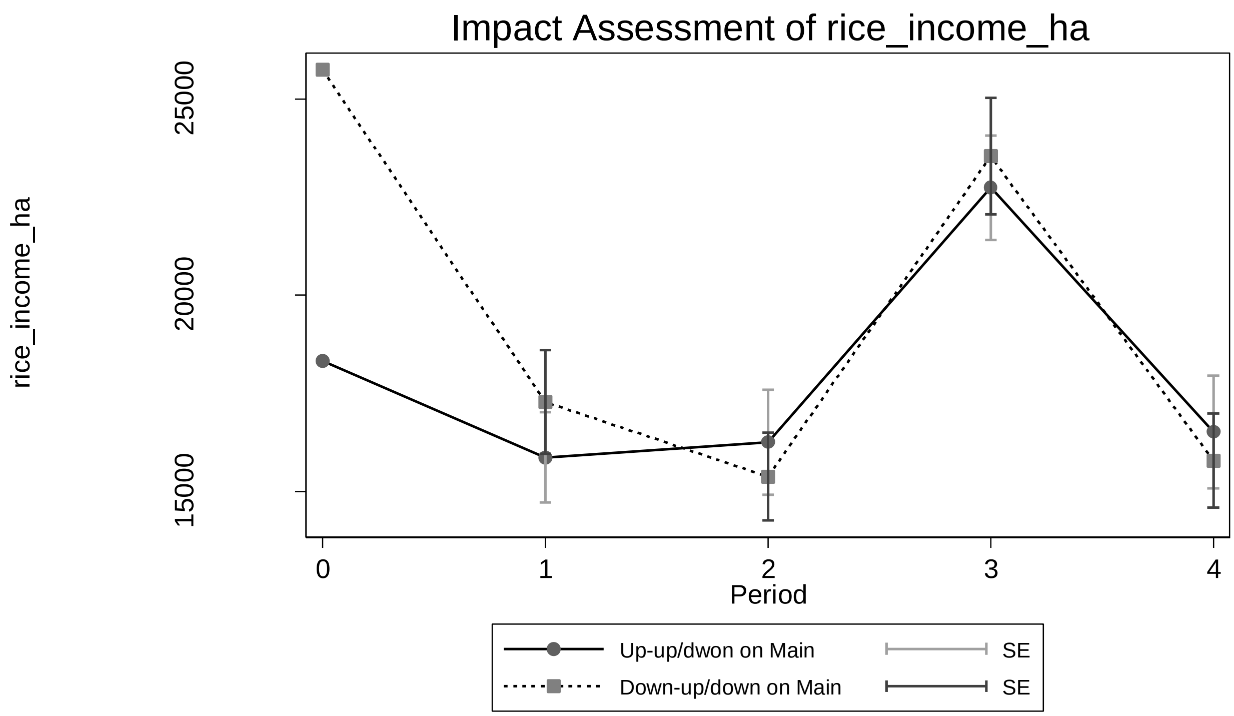
Period	Up-up/ down on main	Down-up/ down on main	Difference	95% interval		p value
1	2439	2569	-130	-396	135	0.34
2	2142	2069	74	-170	317	0.55
3	2643	2742	-99	-367	170	0.47
4	2162	2029	133	-112	379	0.29

Figure 33: Proportional variation of yield from TSA average yield, by location along up- or downstream section of the main canal over the survey period.



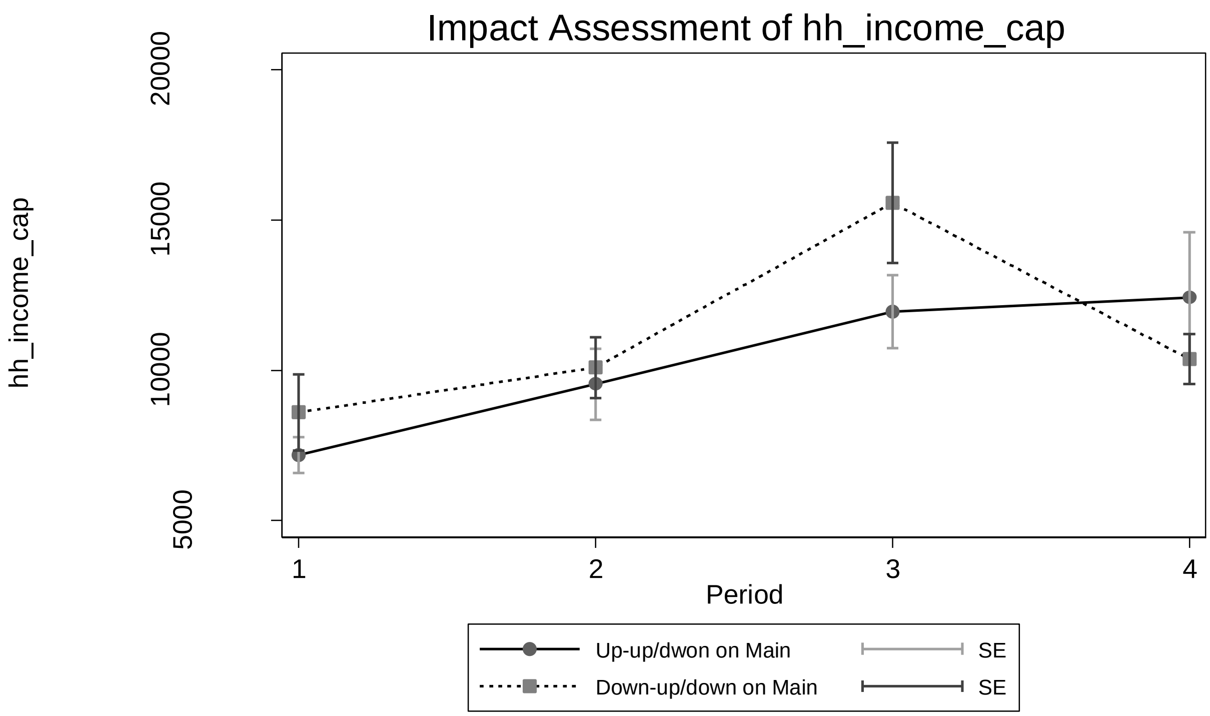
Period	Up-up/ down on main	Down-up/ down on main	Difference	95% interval		p value
1	0.315	0.342	-0.027	-0.084	0.030	0.35
2	0.388	0.367	0.021	-0.040	0.082	0.50
3	0.331	0.284	0.047	-0.001	0.095	0.05
4	0.371	0.357	0.015	-0.053	0.082	0.67

Figure 34. Rice income per hectare, by location along up- or downstream section of the main canal over the survey period.



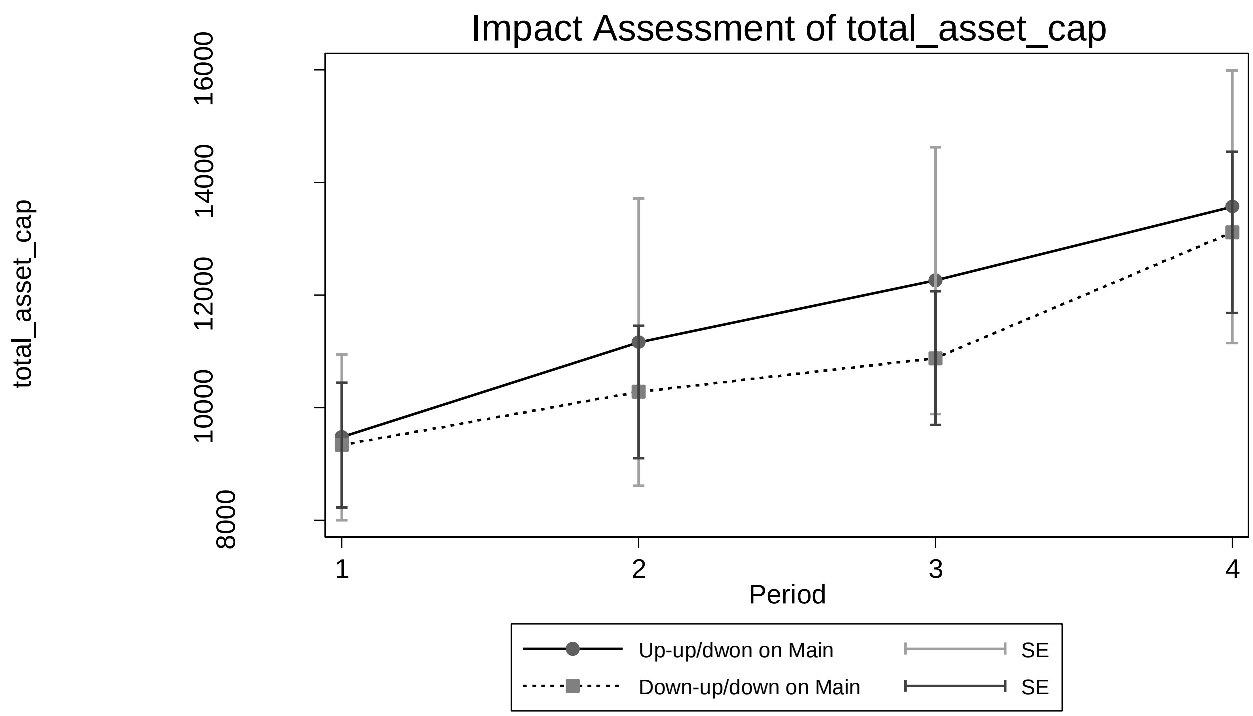
Period	Up-up/ down on main	Down-up/ down on main	Difference	95% interval		p value
1	15870	17281	-1411	-4840	2019	0.42
2	16261	15377	885	-2534	4303	0.61
3	22743	23548	-805	-4707	3097	0.69
4	16524	15788	736	-2944	4415	0.69

Figure 35. Household income per capita, by location along up- or downstream section of the main canal over the survey period.



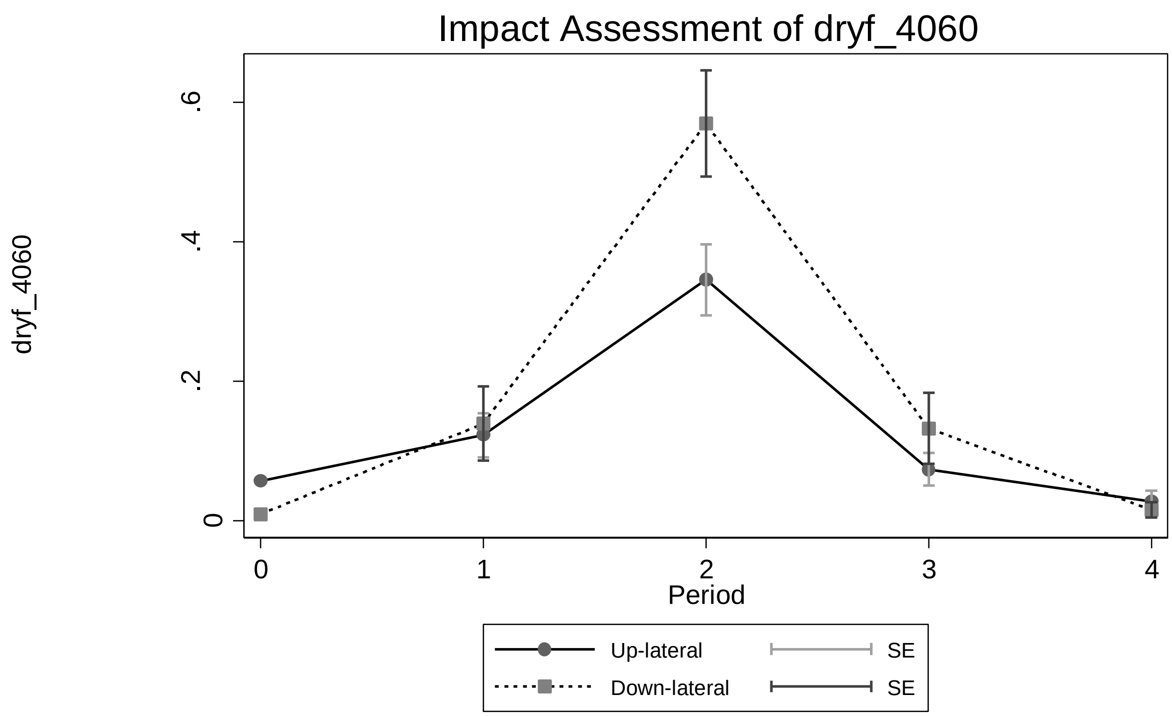
Period	Up-up/ down on main	Down-up/ down on main	Difference	95% interval		p value
1	7172	8596	-1424	-4156	1308	0.31
2	9534	10092	-557	-3610	2495	0.72
3	11954	15568	-3614	-8229	1000	0.12
4	12418	10373	2045	-2511	6601	0.38

Figure 36. Total asset per capita, by location along up- or downstream section of the main canal over the survey period.



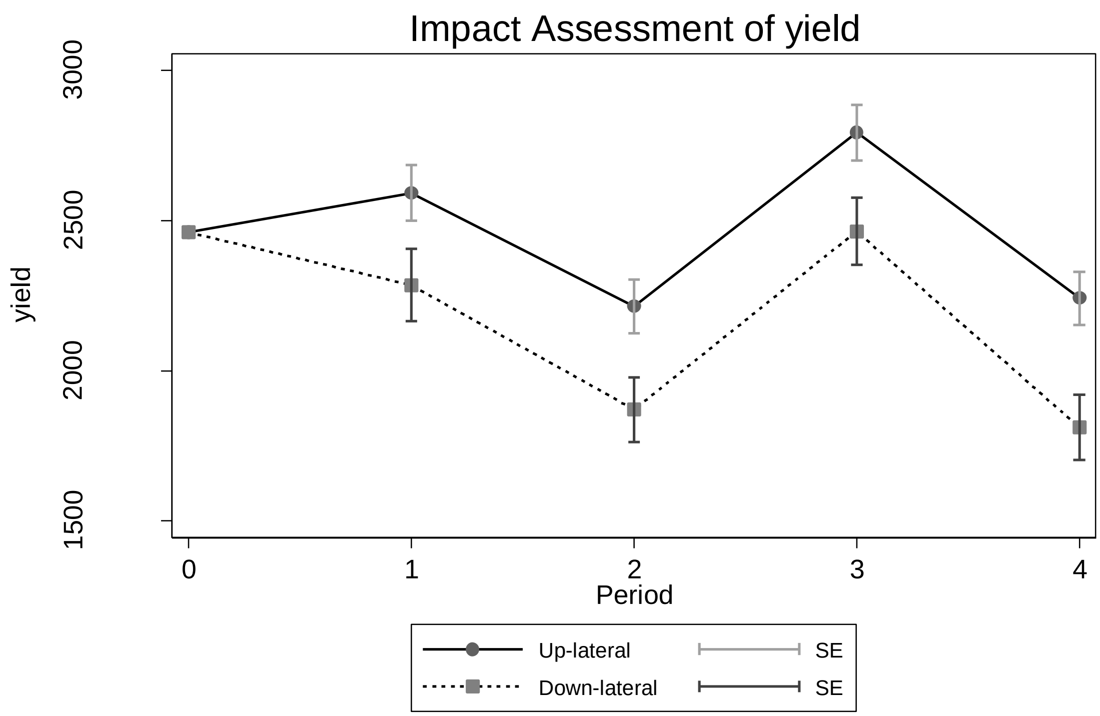
Period	Up-up/ down on main	Down-up/ down on main	Difference	95% interval		p value
1	9475	9338	137	-3477	3751	0.94
2	11165	10284	882	-4626	6390	0.75
3	12258	10882	1376	-3817	6569	0.60
4	13569	13113	457	-5070	5984	0.87

Figure 37. Water stress, by location along laterals over the survey period.



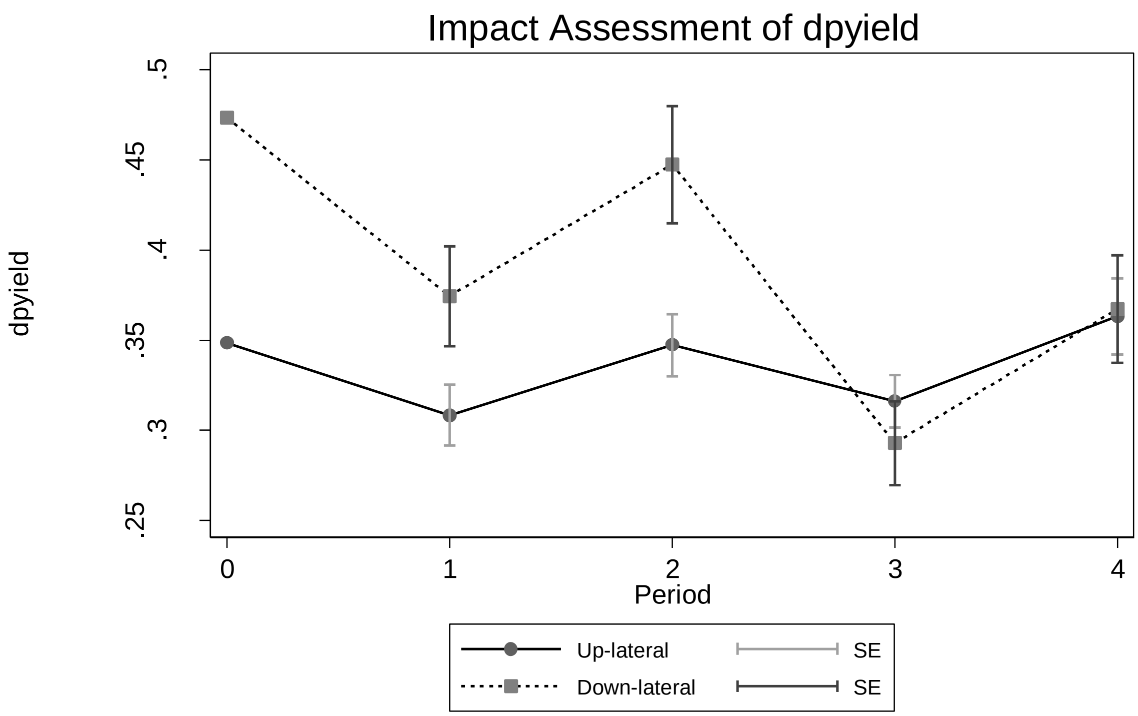
Period	Up-lateral	Down-lateral	Difference	95% interval		p value
1	0.12	0.14	-0.02	-0.14	0.10	0.78
2	0.34	0.57	-0.22	-0.40	0.04	0.01
3	0.07	0.13	-0.06	-0.17	0.05	0.30
4	0.03	0.02	0.01	-0.03	0.05	0.52

Figure 38. Rice yield, by location along laterals over the survey period.



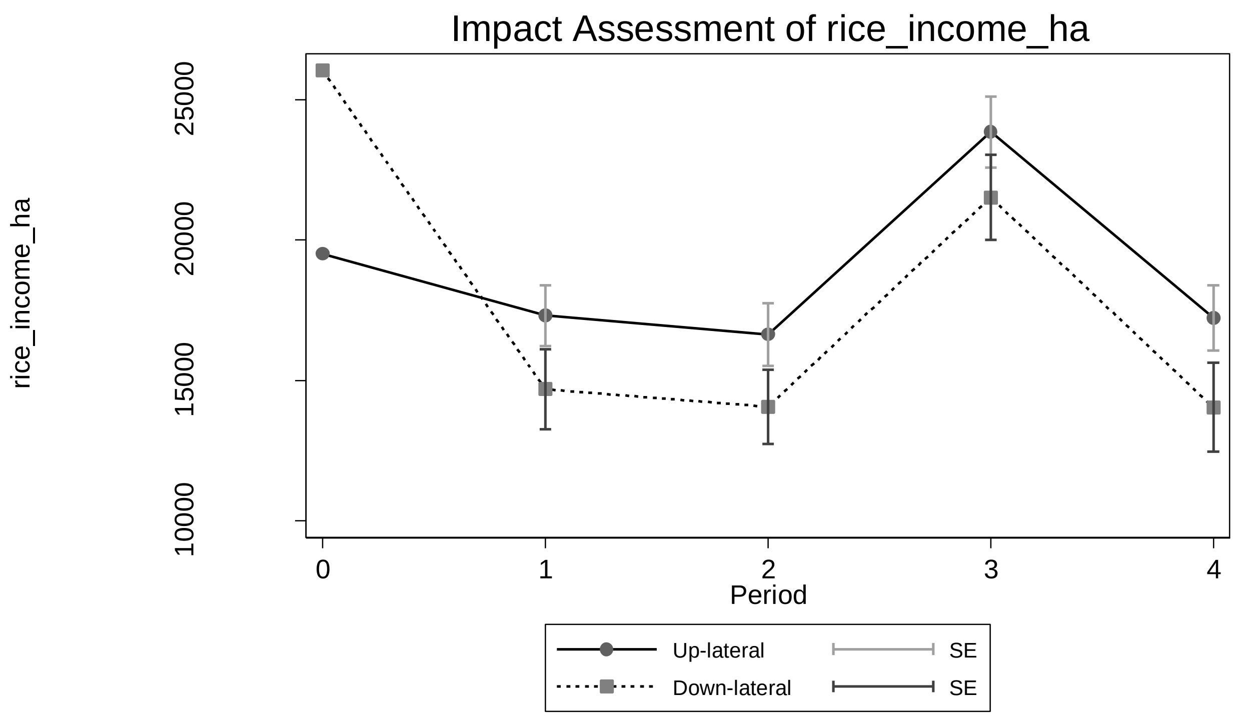
Period	Up-lateral	Down-lateral	Difference	95% interval		p value
1	2592	2285	307	9	605	0.04
2	2213	1870	343	68	619	0.02
3	2793	2464	328	44	612	0.02
4	2241	1812	430	156	703	0.00

Figure 39. Proportional variation of yield from TSA average yield, by location along laterals over the survey period.



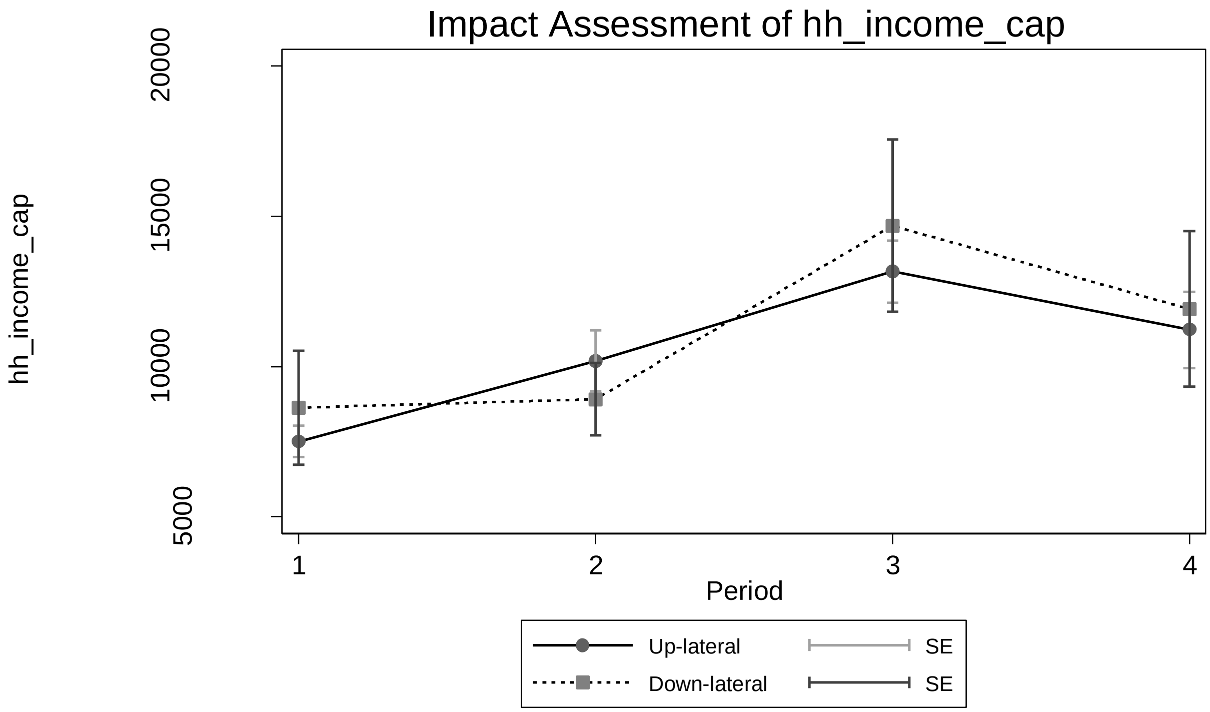
Period	Up-lateral	Down-lateral	Difference	95% interval		p value
1	0.308	0.374	-0.066	-0.130	-0.002	0.04
2	0.347	0.447	-0.100	-0.172	-0.028	0.01
3	0.316	0.293	0.023	-0.031	0.077	0.40
4	0.363	0.367	-0.004	-0.076	0.068	0.91

Figure 40. Rice income per hectare, by location along laterals over the survey period.



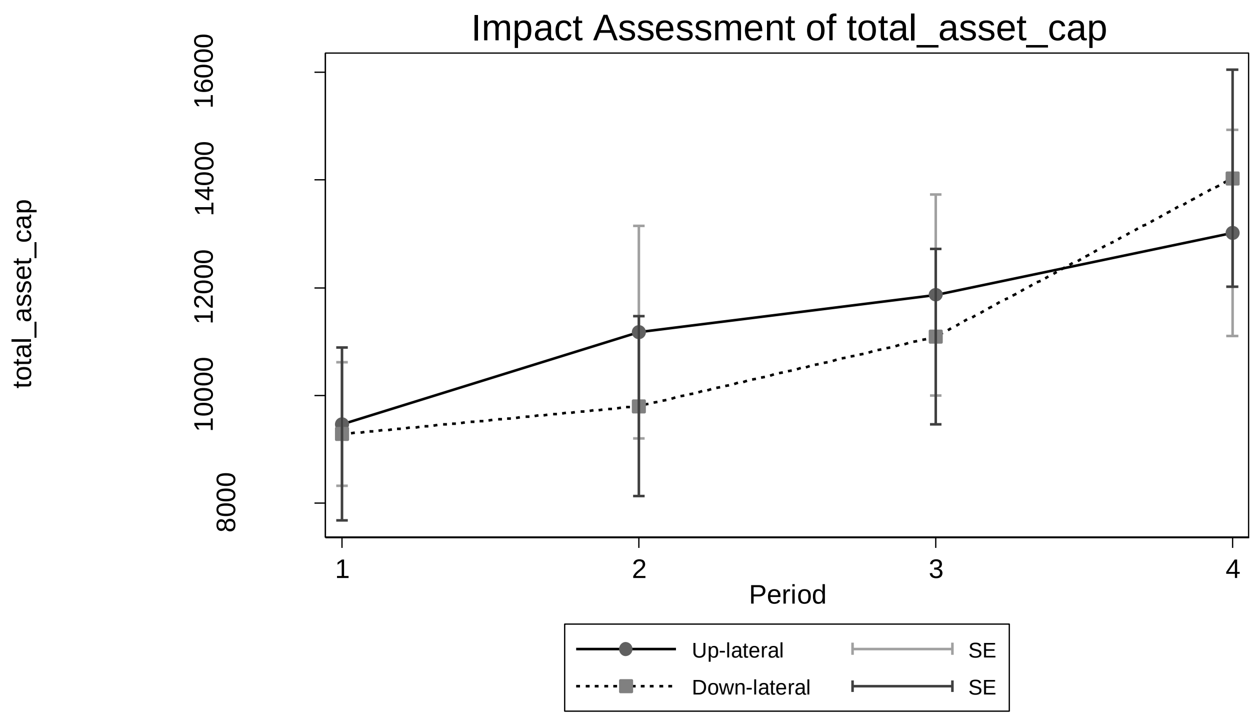
Period	Up-lateral	Down-lateral	Difference	95% interval		p value
1	17317	14691	2627	-881	6134	0.14
2	16638	14066	2572	-842	5986	0.14
3	23855	21524	2331	-1540	6201	0.24
4	17230	14043	3187	-678	7052	0.11

Figure 41. Household income per capita, by location along laterals over the survey period.



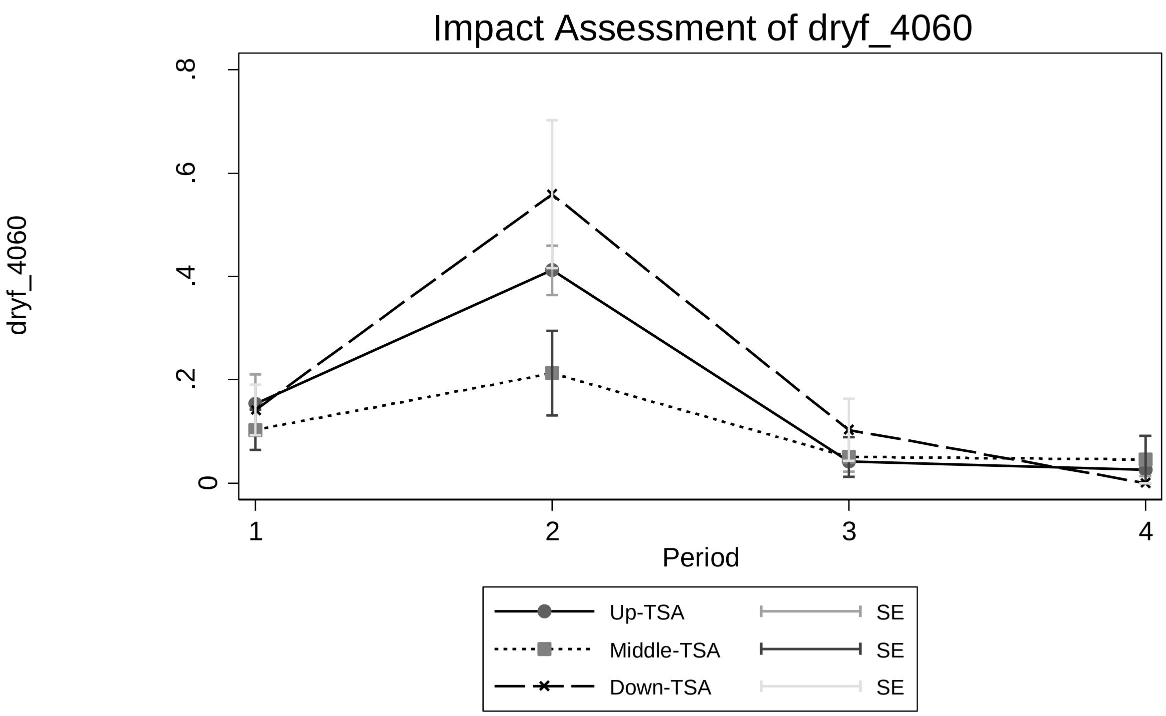
Period	Up-lateral	Down-lateral	Difference	95% interval		p value
1	7506	8628	-1122	-1974	2729	0.57
2	10190	8912	1278	-1793	4349	0.41
3	13154	14684	-1530	-7496	4436	0.61
4	11222	11915	-693	-6360	4974	0.81

Figure 42. Household asset value per capita, by location along laterals over the survey period.



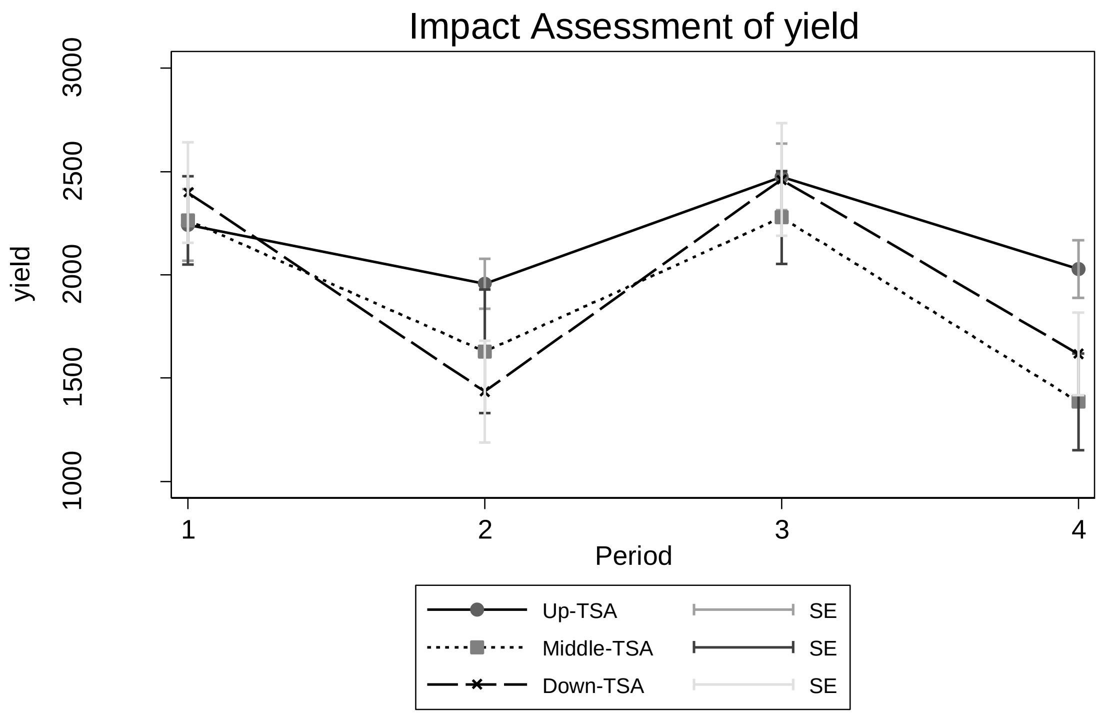
Period	Up-lateral	Down-lateral	Difference	95% interval		p value
1	9467	9279	188	-3687	4061	0.92
2	11174	9800	1374	-3703	6451	0.60
3	11861	11090	771	-4100	5643	0.76
4	13017	14033	-1016	-6473	4441	0.72

Figure 43. Water stress, by location within TSA along downstream of the laterals over the survey period.



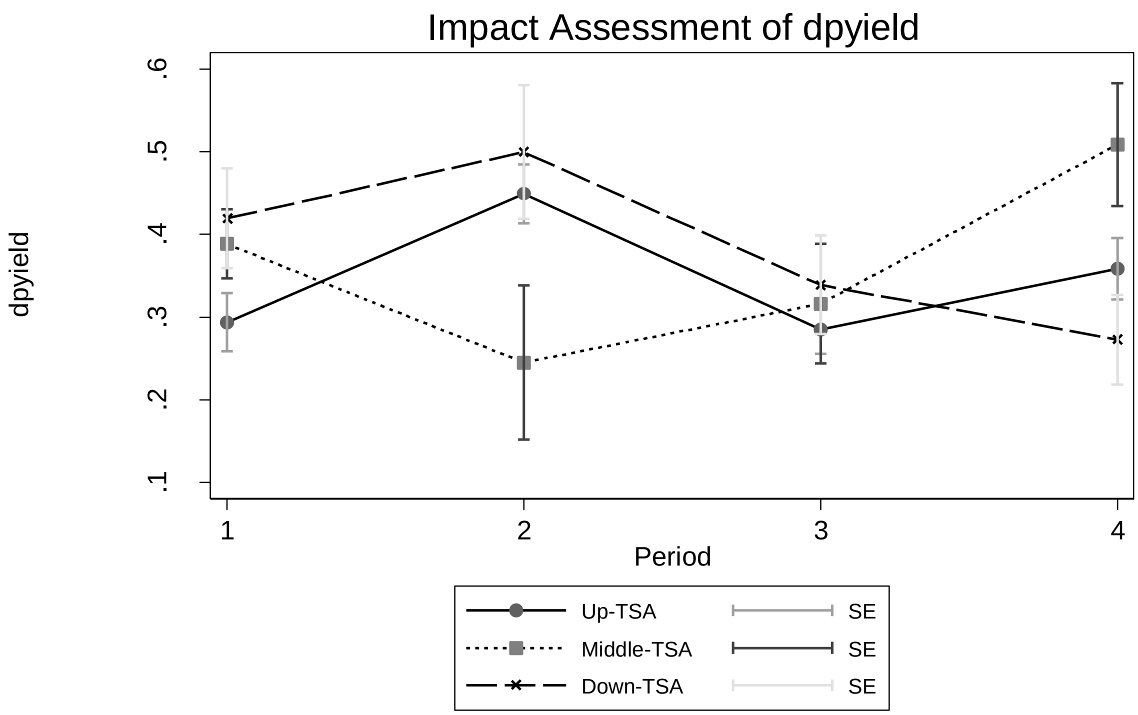
Period	Up-TSA	95% interval		Mid-TSA	95% interval		Down-TSA	95% interval		p value
1	0.15	0.02	0.26	0.10	0.26	0.18	0.14	0.46	0.23	0.71
2	0.41	0.31	0.50	0.21	0.05	0.37	0.55	0.27	0.83	0.04
3	0.04	0.002	0.081	0.05	-0.02	0.13	0.10	-0.01	0.22	0.62
4	0.02	0.003	0.048	0.045	-0.04	0.13	0			0.06

Figure 44. Rice yield, by location within TSA along downstream of the laterals over the survey period.



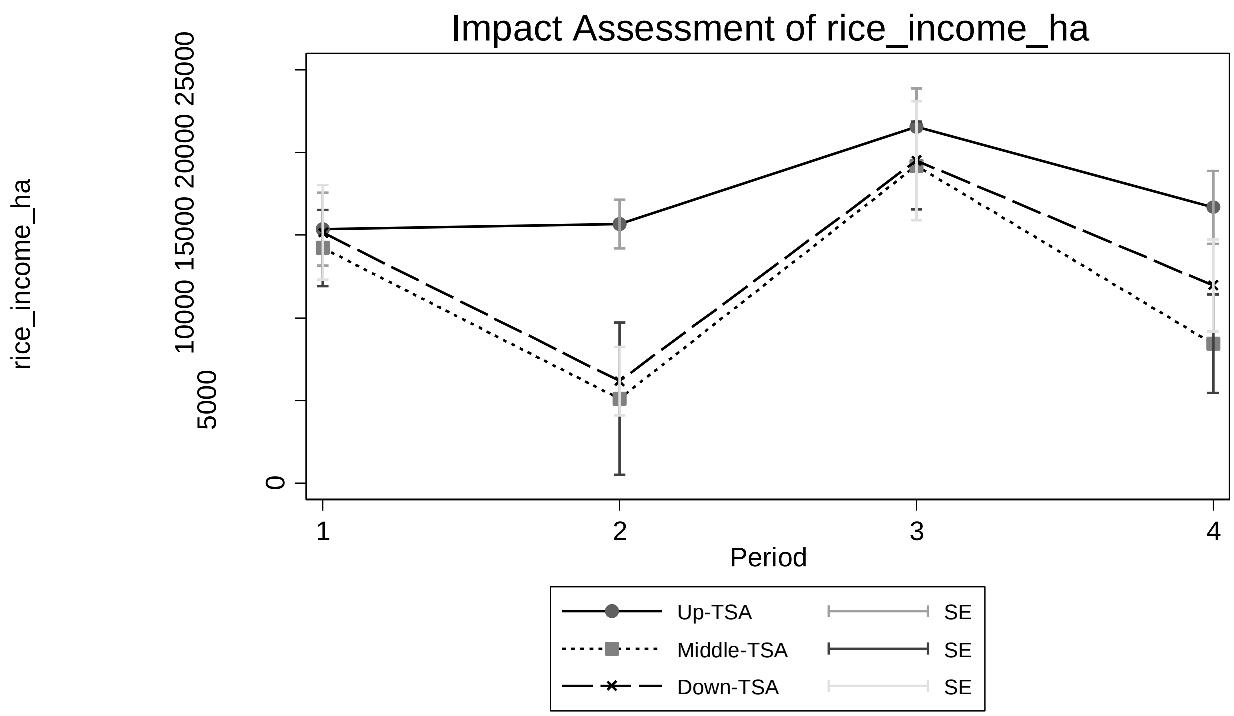
Period	Up-TSA	95% interval		Mid-TSA	95% interval		Down-TSA	95% interval		p value
1	2242	1903	2581	2264	1845	2683	2398	1921	2874	0.87
2	1957	1720	2193	1629	1074	2183	1436	968	1904	0.12
3	2473	2154	2792	2278	1841	2715	2461	1926	2996	0.76
4	2027	1752	2302	1386	930	1842	1617	1227	2008	0.04

Figure 45. Proportional variation of yield from TSA average yield, by location within TSA along downstream of the laterals over the survey period.



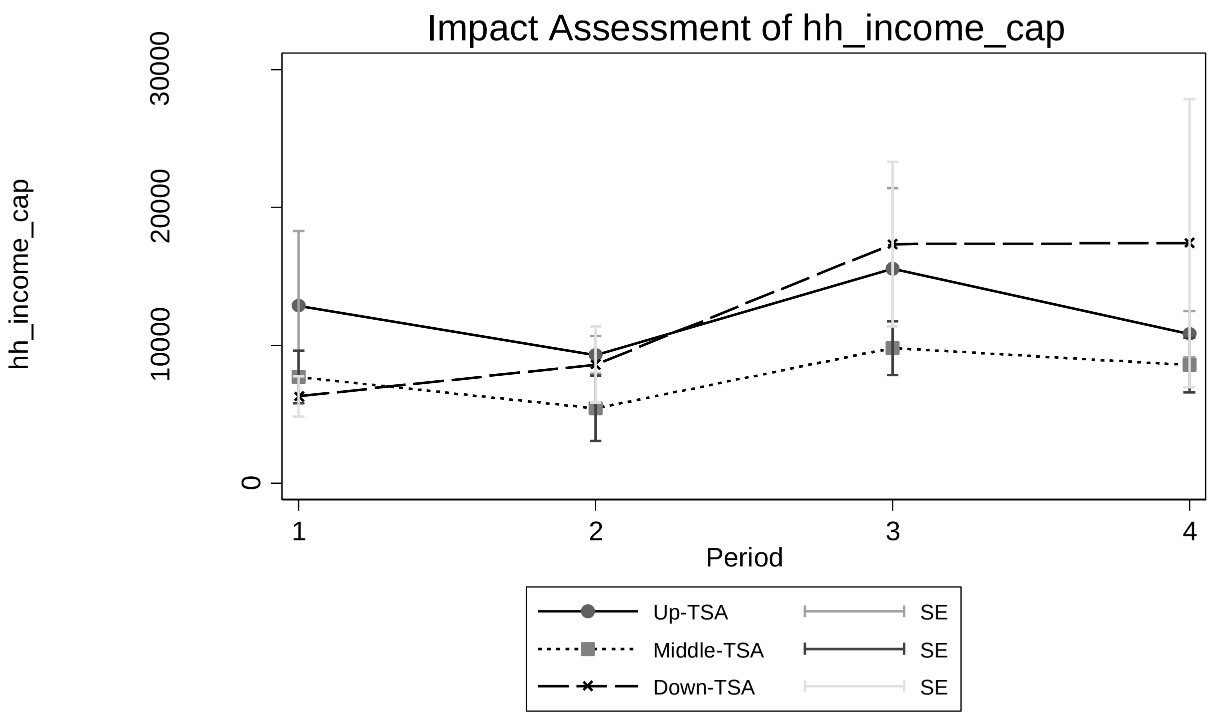
Period	Up-TSA	95% interval		Mid-TSA	95% interval		Down-TSA	95% interval		p value
1	0.294	0.224	0.363	0.389	0.307	0.471	0.420	0.301	0.538	0.10
2	0.449	0.379	0.519	0.245	0.073	0.418	0.500	0.346	0.654	0.07
3	0.285	0.227	0.342	0.316	0.175	0.457	0.339	0.227	0.455	0.69
4	0.358	0.285	0.432	0.509	0.364	0.653	0.273	0.167	0.379	0.04

Figure 46. Rice income per hectare, by location within TSA along downstream of the laterals over the survey period.



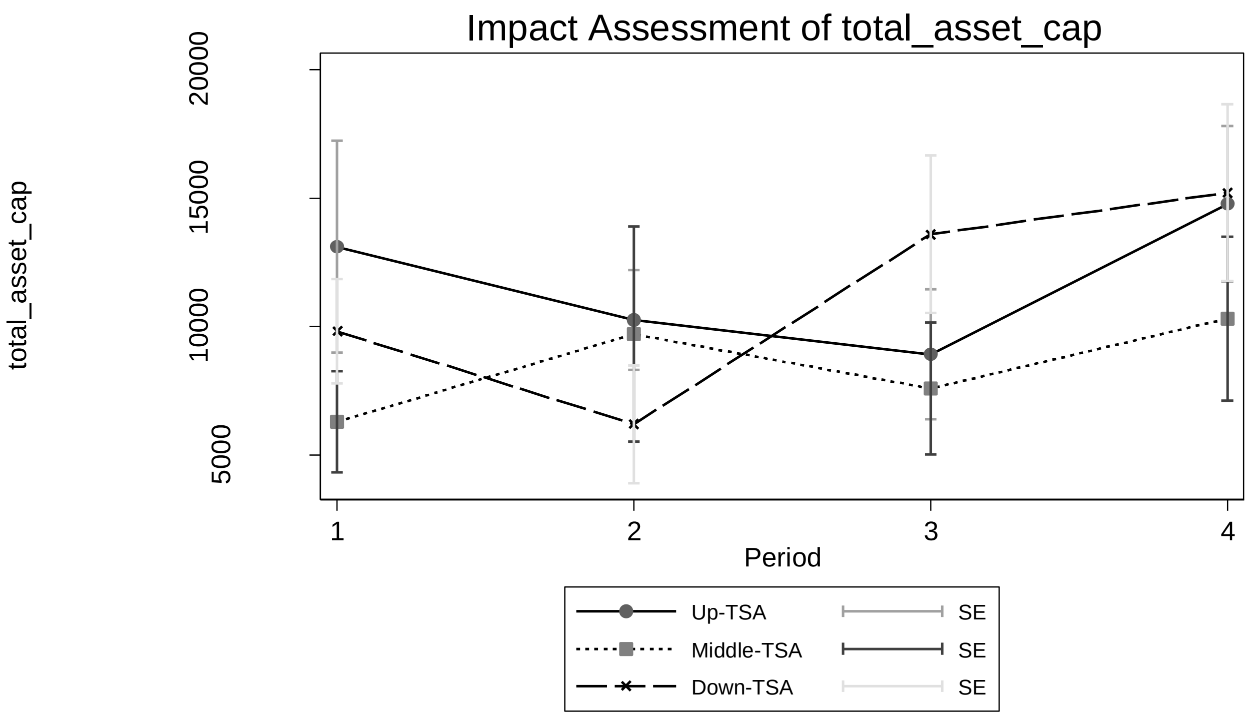
Period	Up-TSA	95% interval		Mid-TSA	95% interval		Down-TSA	95% interval		p value
1	15364	10999	19729	14225	9708	18742	15163	9524	20802	0.93
2	15669	12782	18555	5103	-3423	13629	6173	2236	10111	0.00
3	21548	16955	26142	19211	14075	24348	19514	12464	26564	0.78
4	16691	12348	21034	8425	2647	14203	11960	6541	17380	0.07

Figure 47. Household income per capita, by location within TSA along the downstream part of laterals over the survey period.



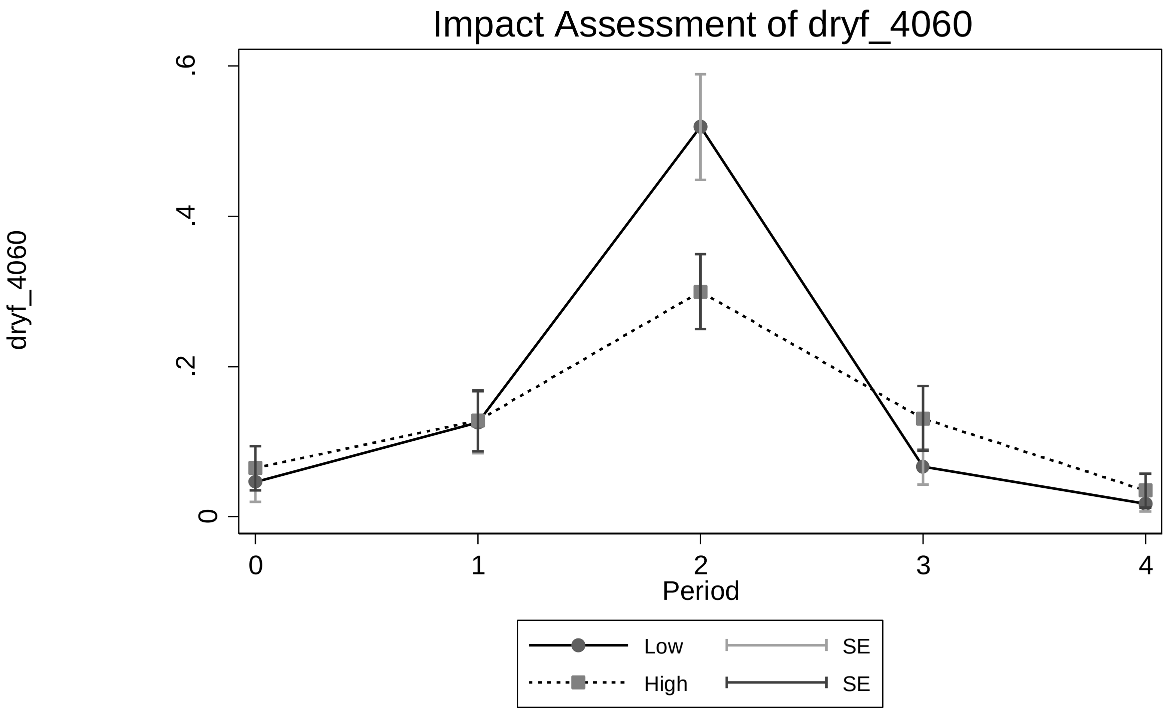
Period	Up-TSA	95% interval		Mid-TSA	95% interval		Down-TSA	95% interval		p value
1	12856	2180	23532	7709	4018	11400	6307	3425	9189	0.47
2	9310	6588	12031	5431	1061	9802	8614	3347	13881	0.33
3	15572	4004	27140	9806	6017	13595	17345	5643	29048	0.35
4	10829	7544	14114	8573	4769	12377	17424	-2967	37814	0.52

Figure 48. Household asset value per capita. by location within TSA along the downstream part of laterals over the survey period.



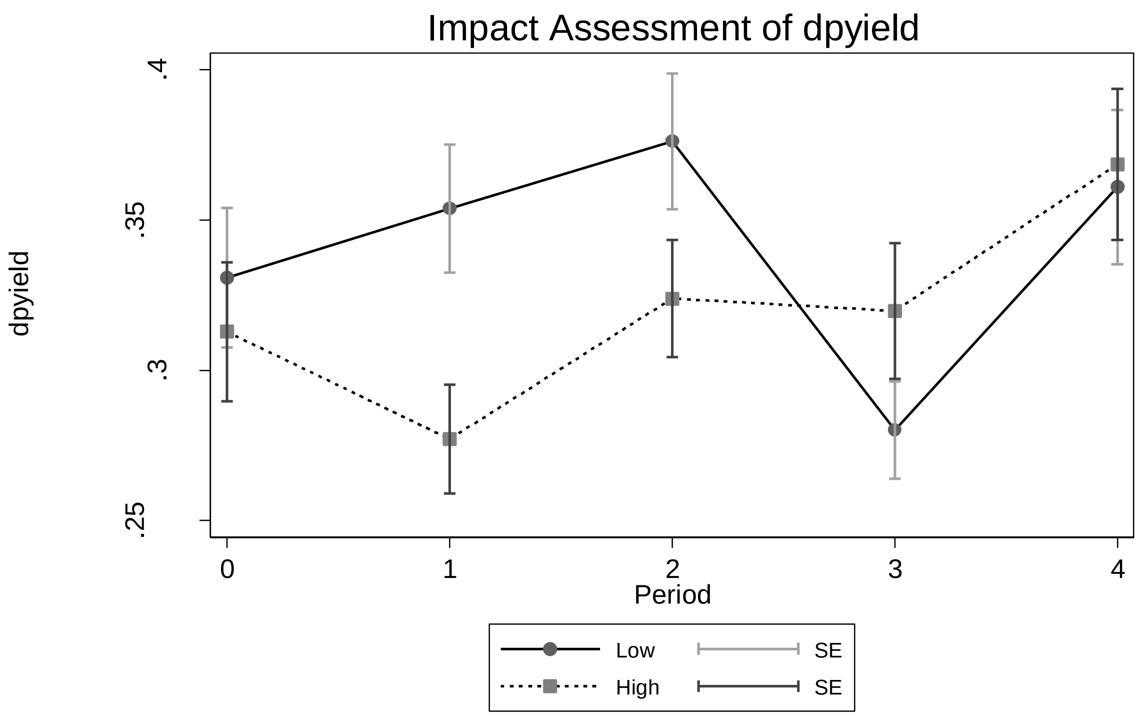
Period	Up-TSA	95% interval		Mid-TSA	95% interval		Down-TSA	95% interval		p value
1	13108	5001	21215	6293	2427	10160	9819	5817	13820	0.23
2	10254	6423	14086	9705	1932	17478	6204	1830	17478	0.38
3	8927	3917	13938	7593	2591	12594	13595	7603	19587	0.3
4	14777	8805	20749	10312	4120	16503	15216	8494	21939	0.49

Figure 49. Water stress, by rate of attendance in TSA meetings over the survey period.



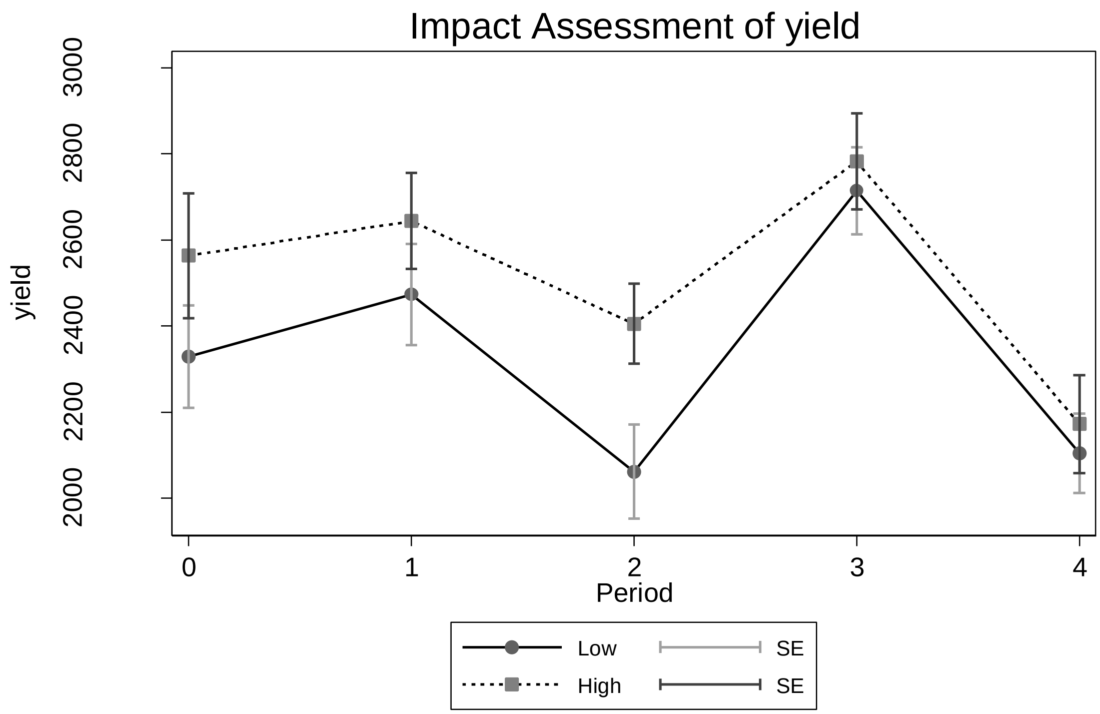
Period	Low	High	Difference	95% interval		p value
1	0.12	0.12	-0.00	-0.11	0.11	0.97
2	0.51	0.30	0.30	0.50	0.38	0.01
3	0.07	0.13	-0.06	-0.16	0.03	0.19
4	0.02	0.04	-0.2	-0.07	0.03	0.47

Figure 50. Proportional variation of yield from TSA average yield, by rate of attendance in TSA meetings over the survey period.



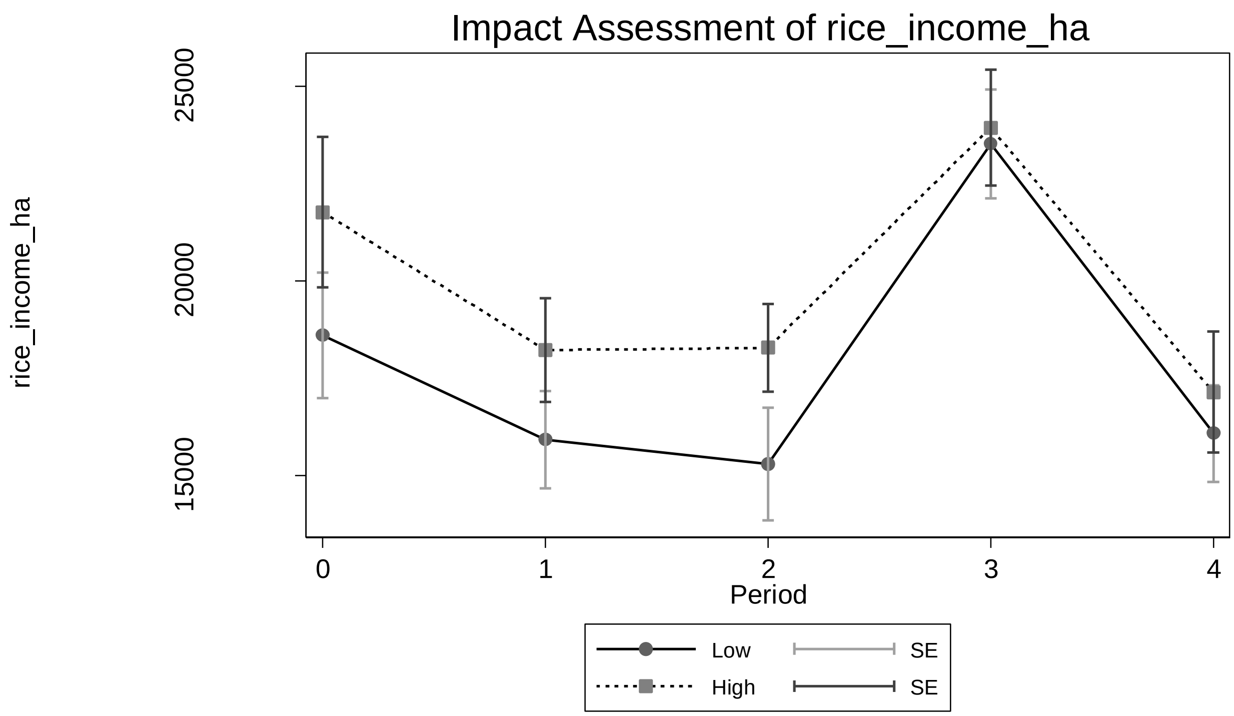
Period	Low	High	Difference	95% interval		p value
1	0.354	0.277	0.077	0.220	0.132	0.01
2	0.376	0.324	0.052	-0.006	0.111	0.08
3	0.280	0.320	-0.040	-0.094	0.015	0.15
4	0.361	0.369	-0.008	-0.078	0.063	0.83

Figure 51. Rice yield, by rate of attendance in TSA meetings over the survey period.



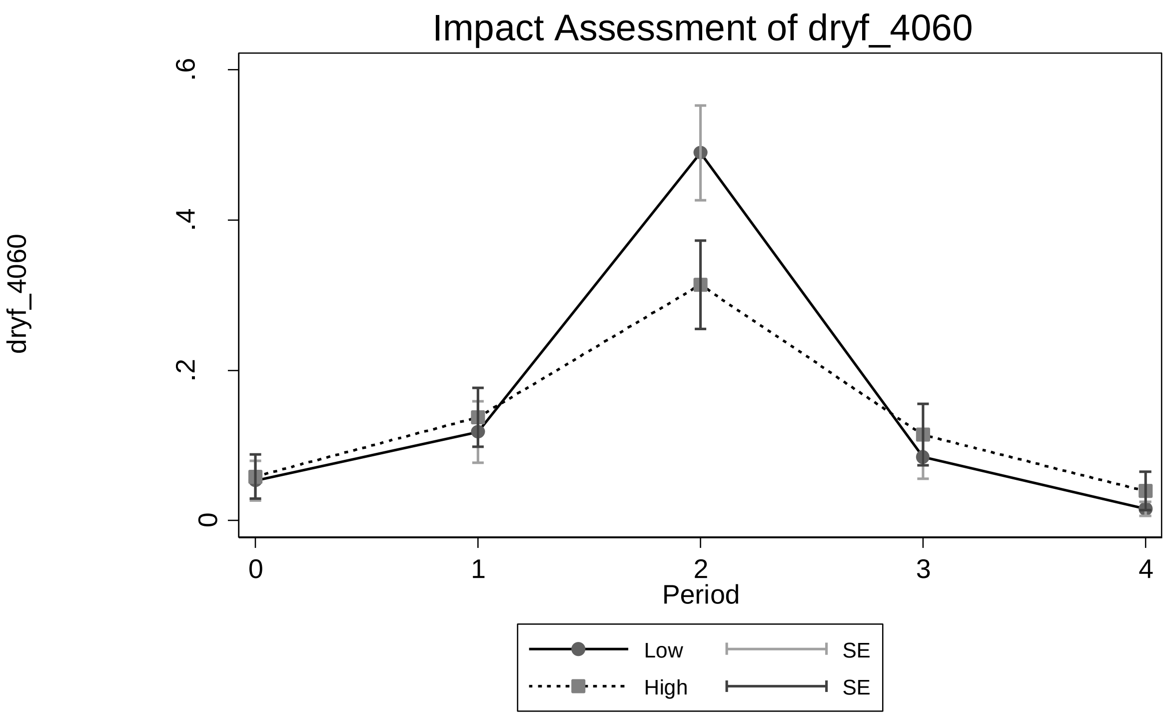
Period	Low	High	Difference	95% interval		p value
1	2474	2644	170	-488	148	0.29
2	2062	2405	-344	-625	-62	0.02
3	2714	2783	-69	-366	228	0.65
4	2104	2172	-68	-355	219	0.64

Figure 52. Rice income per hectare, by rate of attendance in TSA meetings over the survey period.



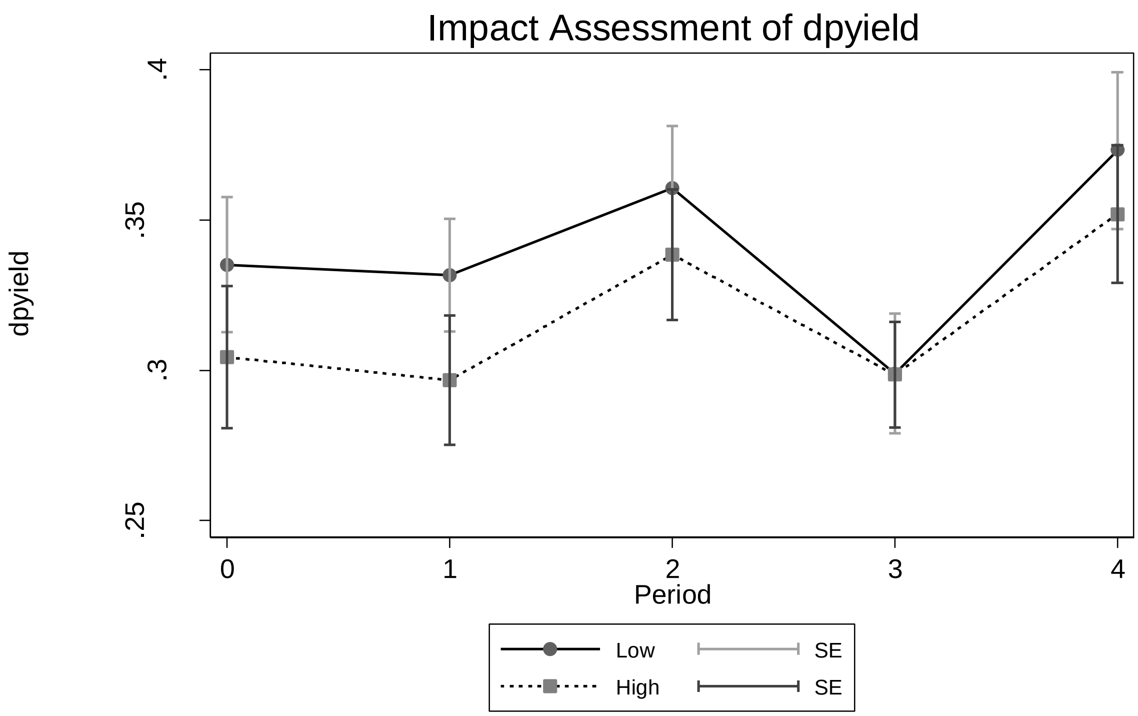
Period	Low	High	Difference	95% interval		p value
1	15917	18222	-2305	-5886	1276	0.21
2	15293	18278	-2985	-6590	620	0.10
3	23517	23930	-412	-4427	3602	0.84
4	16077	17140	-1063	-4966	2840	0.59

Figure 53. Water stress, by rate of attendance in TSA cleaning activities over the survey period.



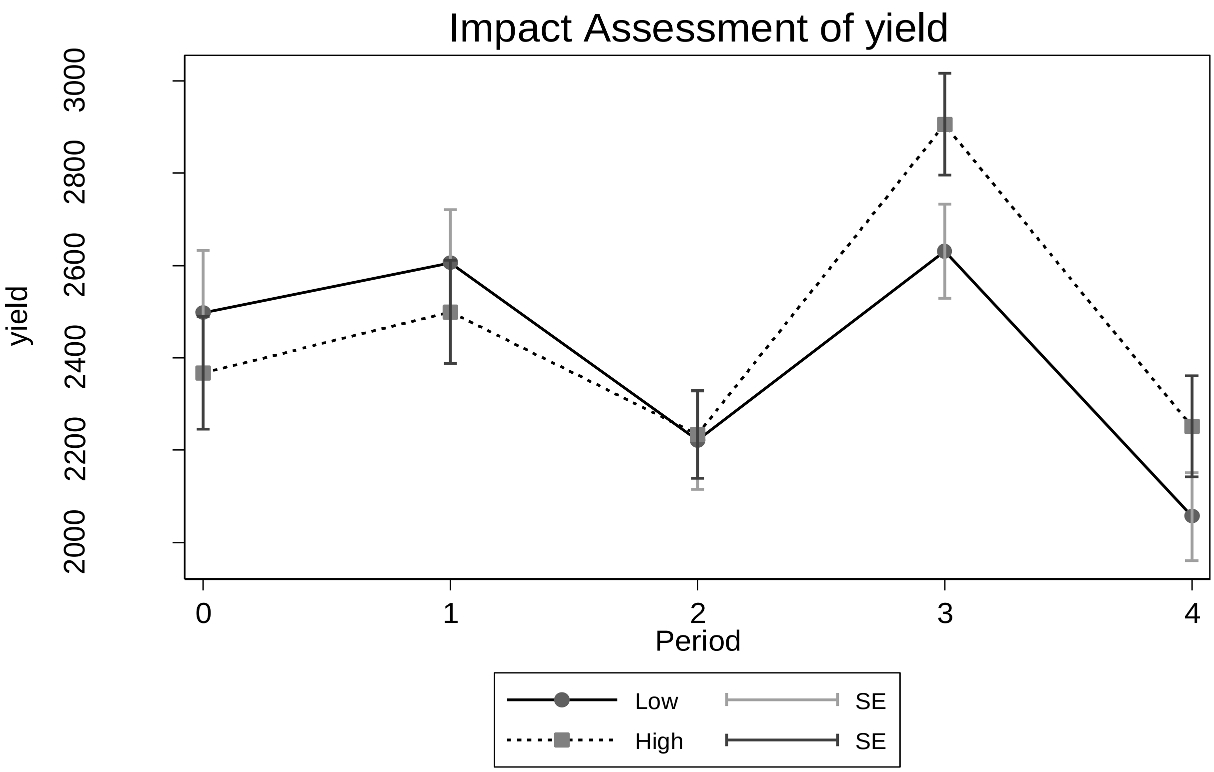
Period	Low	High	Difference	95% interval		p value
1	0.12	0.14	-0.02	-0.13	0.09	0.73
2	0.48	0.31	0.17	0.01	0.34	0.04
3	0.08	0.11	-0.03	-0.13	0.06	0.54
4	0.02	0.04	-0.02	-0.07	0.03	0.38

Figure 54. Proportional variation of yield from TSA average yield, by rate of attendance in TSA cleaning activities over the survey period.



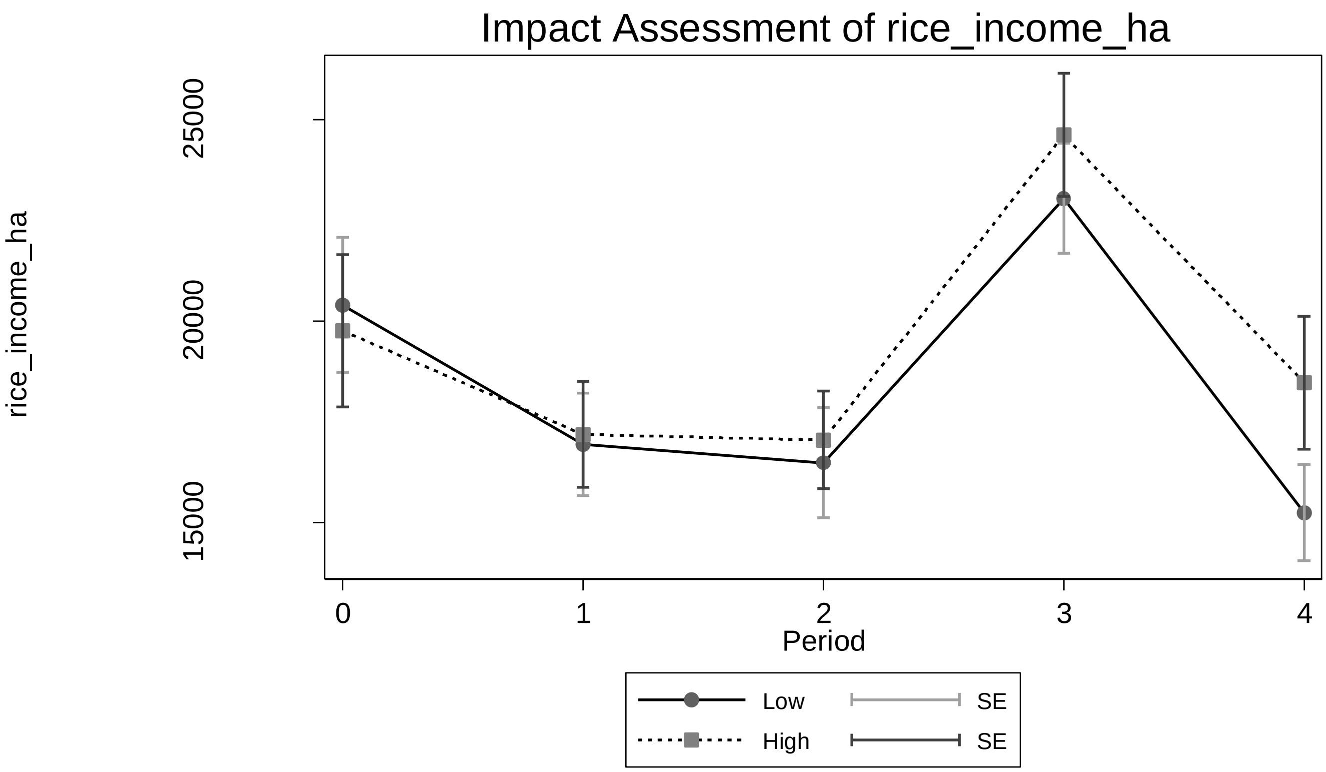
Period	Low	High	Difference	95% interval		p value
1	0.332	0.297	0.035	-0.021	0.091	0.22
2	0.361	0.338	0.022	-0.037	0.081	0.46
3	0.299	0.299	0.000	-0.052	0.053	0.99
4	0.373	0.352	0.021	-0.047	0.089	0.54

Figure 55. Rice yield, by rate of attendance in TSA cleaning activities over the survey period.



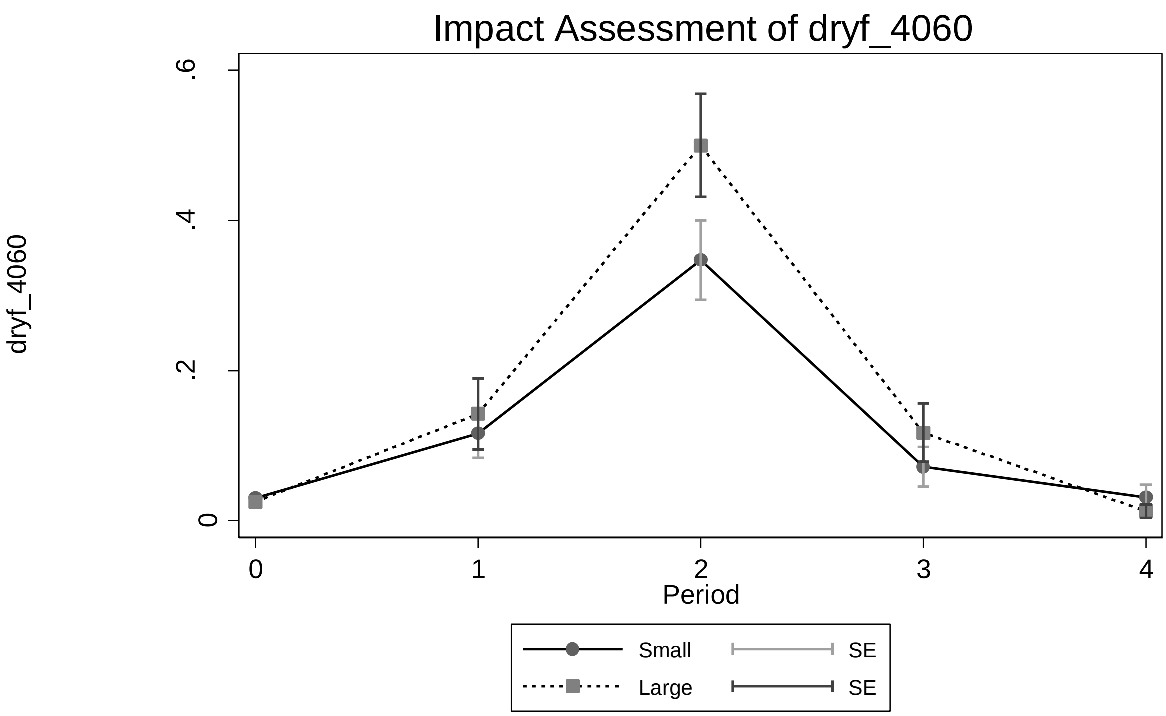
Period	Low	High	Difference	95% interval		p value
1	2606	2499	106	-209	421	0.51
2	2221	2234	-13	-294	267	0.93
3	2631	2905	-275	-569	20	0.07
4	2056	2251	-195	-480	91	0.18

Figure 56. Rice income per hectare, by rate of attendance in TSA cleaning activities over the survey period.



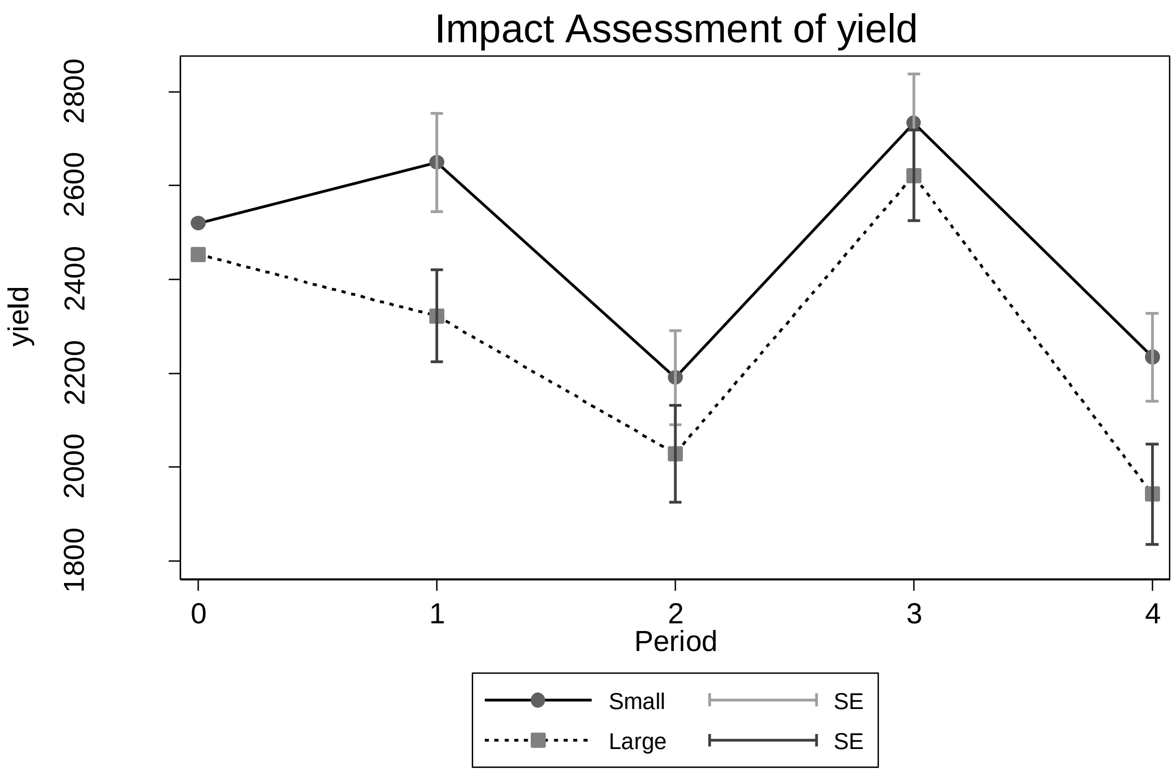
Period	Low	High	Difference	95% interval		p value
1	16948	17188	-240	-3833	3353	0.90
2	16485	17049	-564	-4136	3008	0.76
3	23048	24623	-1575	-5600	2450	0.44
4	15248	18475	-3227	-7233	780	0.11

Figure 57. Water stress, by landholding size, over the survey period.



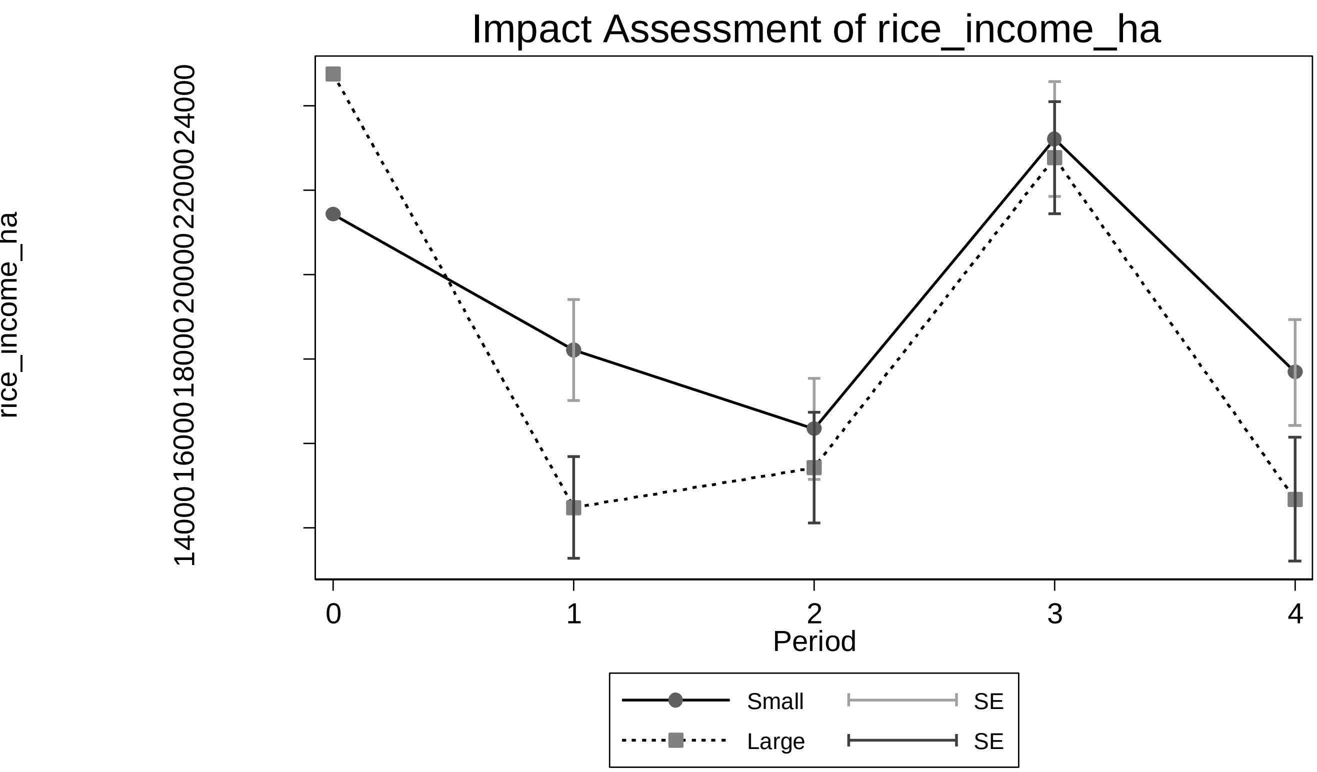
Period	Small	Large	Difference	95% Interval		p value
1	0.12	0.14	-0.03	-0.14	0.09	0.66
2	0.35	0.50	-0.15	-0.31	0.02	0.09
3	0.07	0.11	-0.04	-0.13	0.05	0.34
4	0.03	0.01	0.02	-0.02	0.05	0.34

Figure 58. Rice yield, by landholding size, over the survey period.



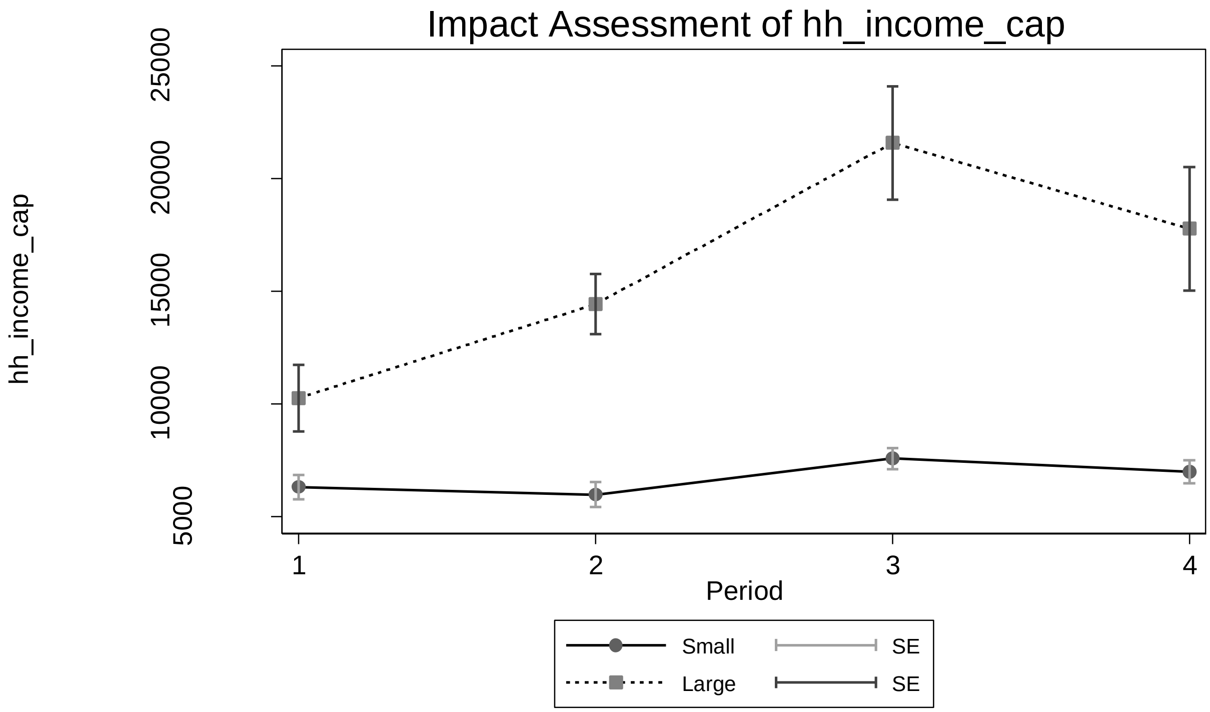
Period	Small	Large	Difference	95% interval		p value
1	2632	2290	342	67	617	0.02
2	2166	2029	137	-144	417	0.34
3	2719	2622	98	-184	379	0.50
4	2208	1943	265	-11	541	0.06

Figure 59. Rice income per hectare, by landholding size, over the survey period.



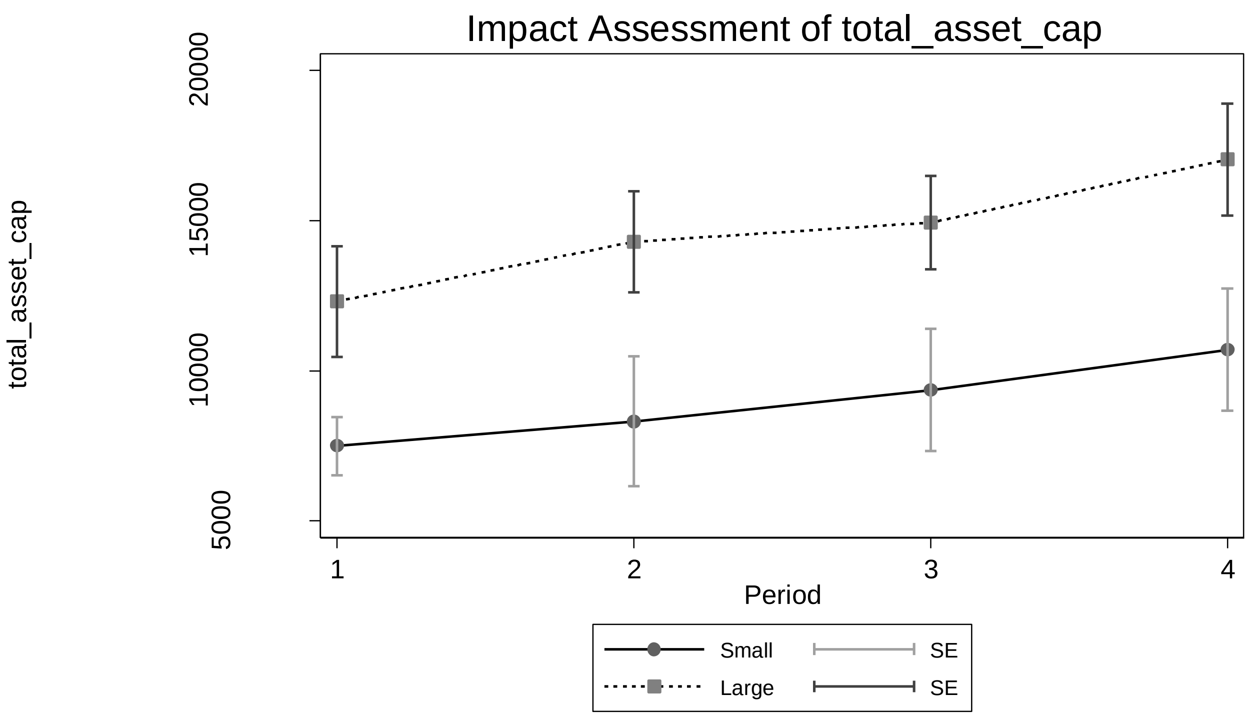
Period	Small	Large	Difference	95% interval		p value
1	17953	14257	3696	393	699	0.03
2	16147	15423	723	-2753	4200	0.68
3	23268	22776	492	-3288	4272	0.80
4	17313	14680	2633	-1135	6402	0.17

Figure 60. Household income per capita, by landholding size, over the survey period.



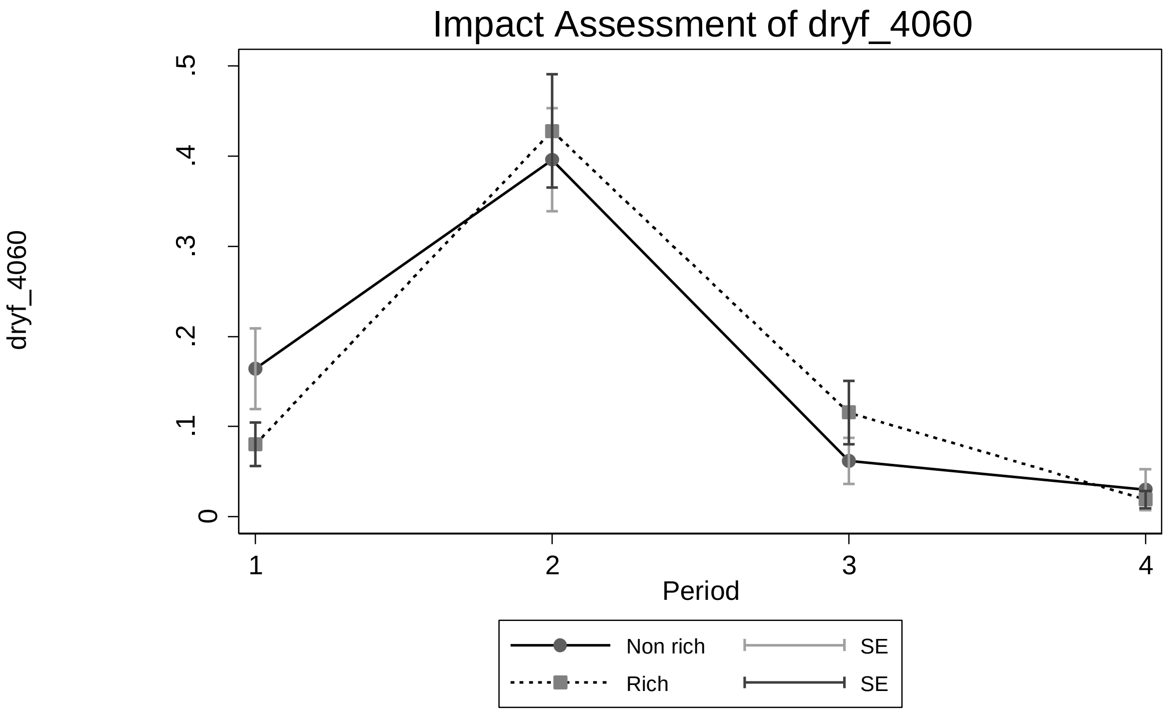
Period	Small	Large	Difference	95% interval		p value
1	6360	10216	-3856	-6974	-738	0.02
2	5979	14428	1336	-11293	-5605	0.00
3	7667	21588	-13921	-18929	-8913	0.00
4	6987	17776	-10789	-16279	-5300	0.00

Figure 61. Household asset value per capita, by landholding size, over the survey period.



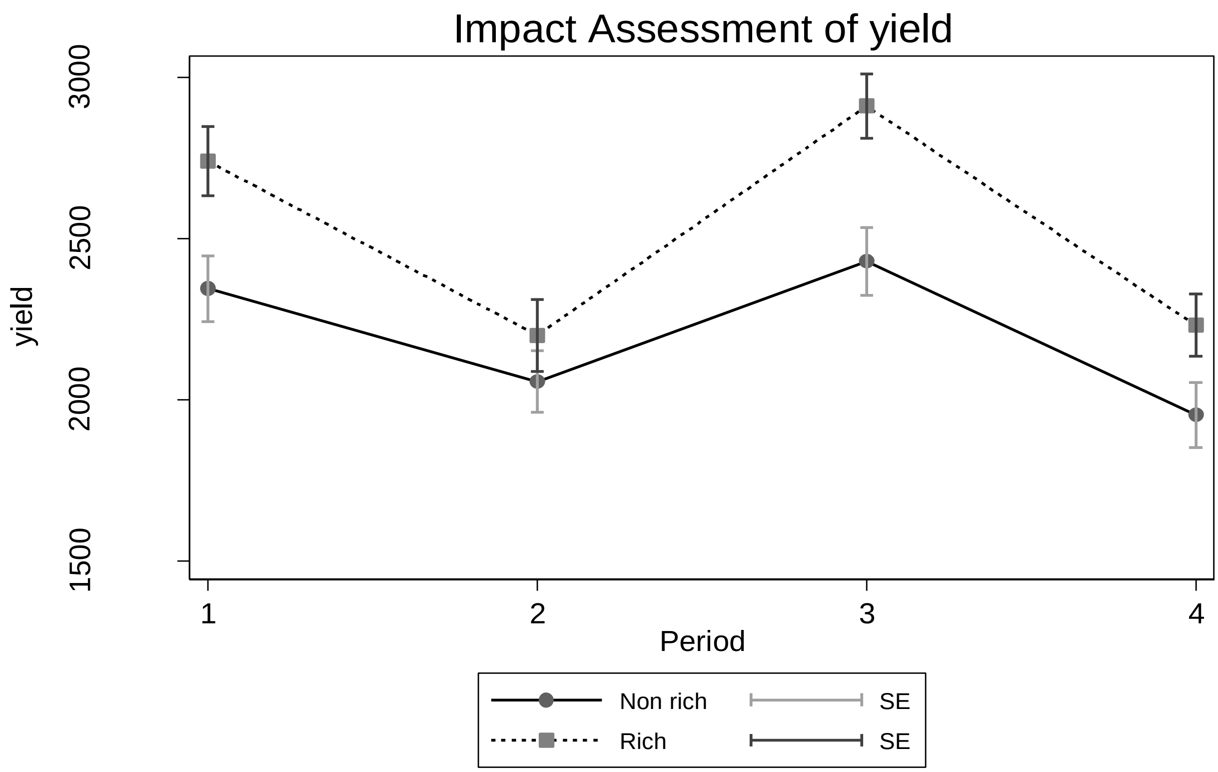
Period	Small	Large	Difference	95% interval		p value
1	7537	12415	-4878	-8990	-766	0.02
2	8376	14292	-5916	-11342	-490	0.03
3	9448	14935	-5487	-10580	-394	0.04
4	10764	17030	-6267	-11741	-792	0.03

Figure 62. Water stress, by asset holding size, over the survey period.



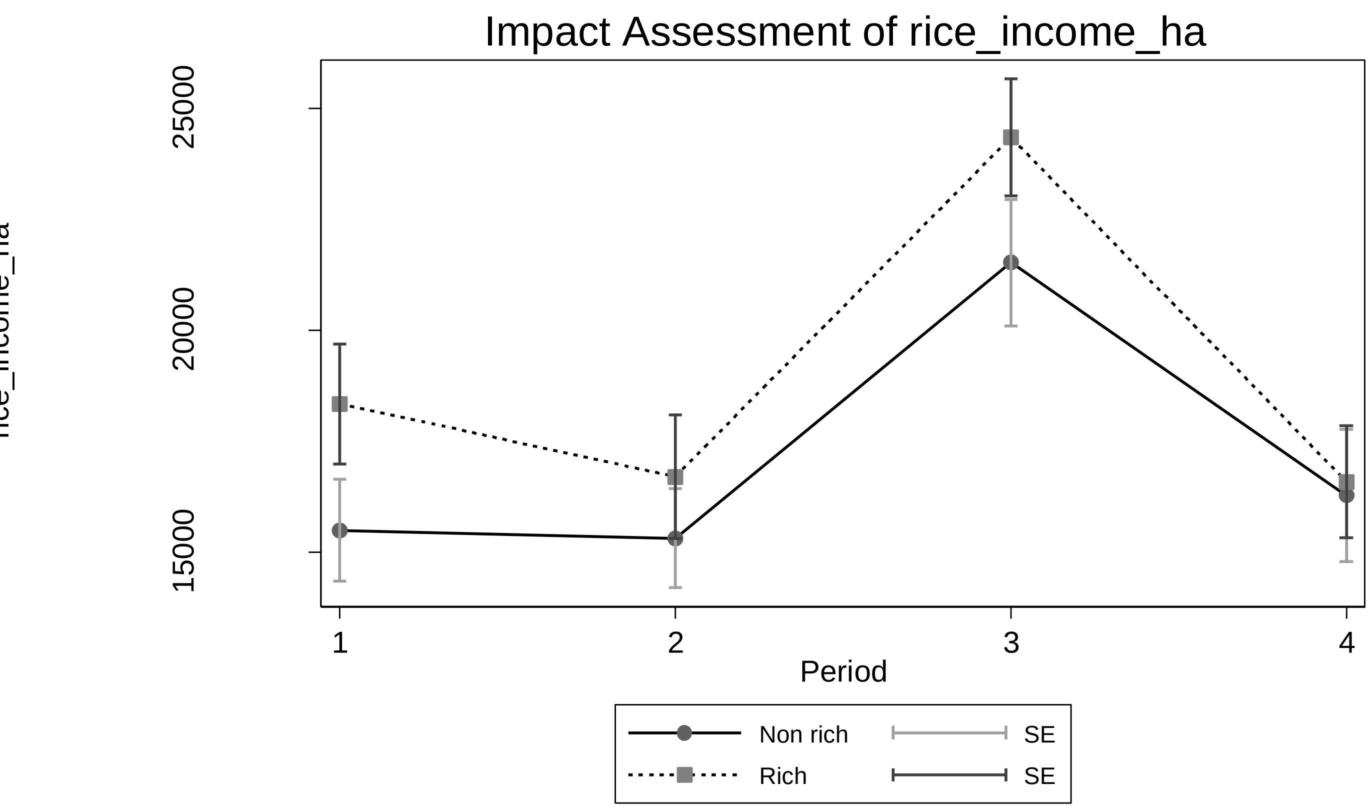
Period	Non rich	Rich	Difference	95% interval		p value
1	0.16	0.08	0.08	-0.02	0.18	0.11
2	0.39	0.43	-0.04	-0.21	0.12	0.63
3	0.06	0.12	-0.06	-0.14	0.03	0.20
4	0.03	0.02	0.01	-0.03	0.06	0.67

Figure 63. Rice yield, by asset holding size, over the survey period.



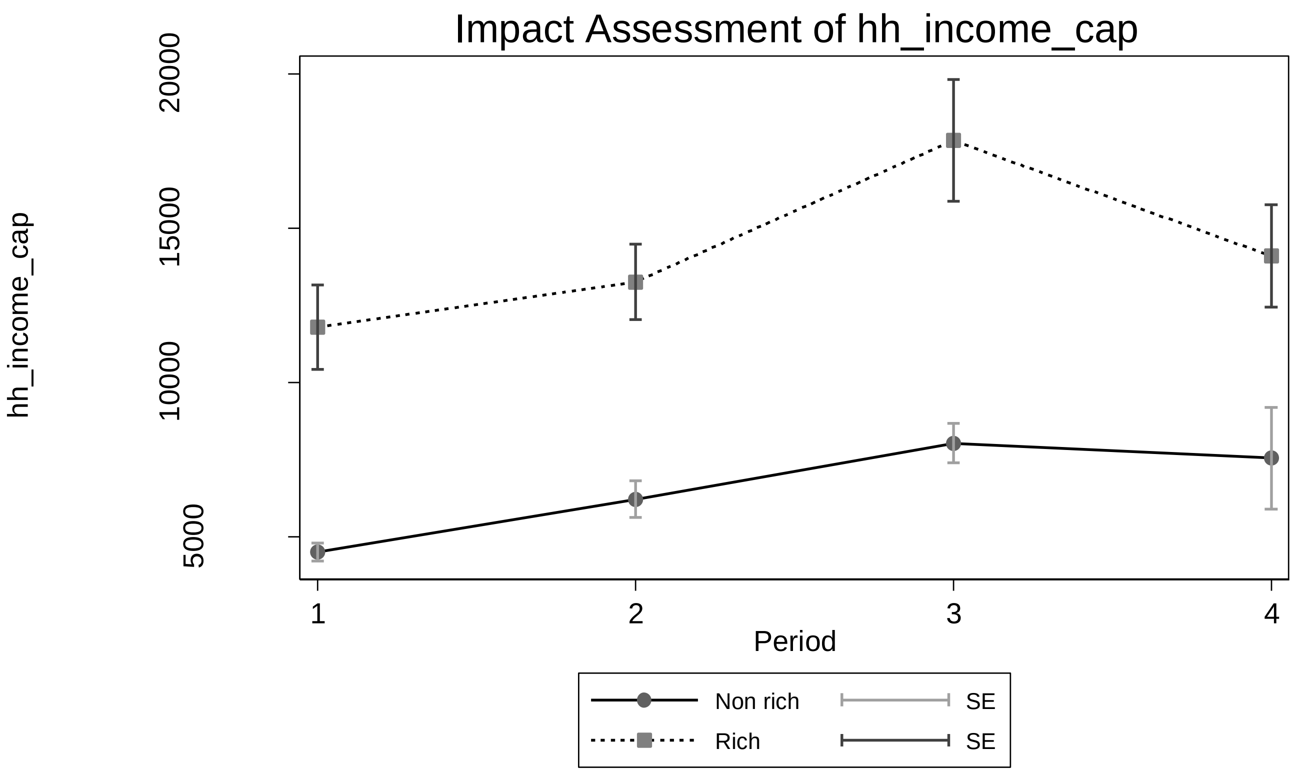
Period	Non rich	Rich	Difference	95% interval		p value
1	2322	2718	-396	-683	-108	0.01
2	2056	2169	-112	-396	172	0.44
3	2430	2899	-470	-756	-183	0.00
4	1953	2204	-251	-523	22	0.07

Figure 64. Rice income per hectare, by asset holding size, over the survey period.



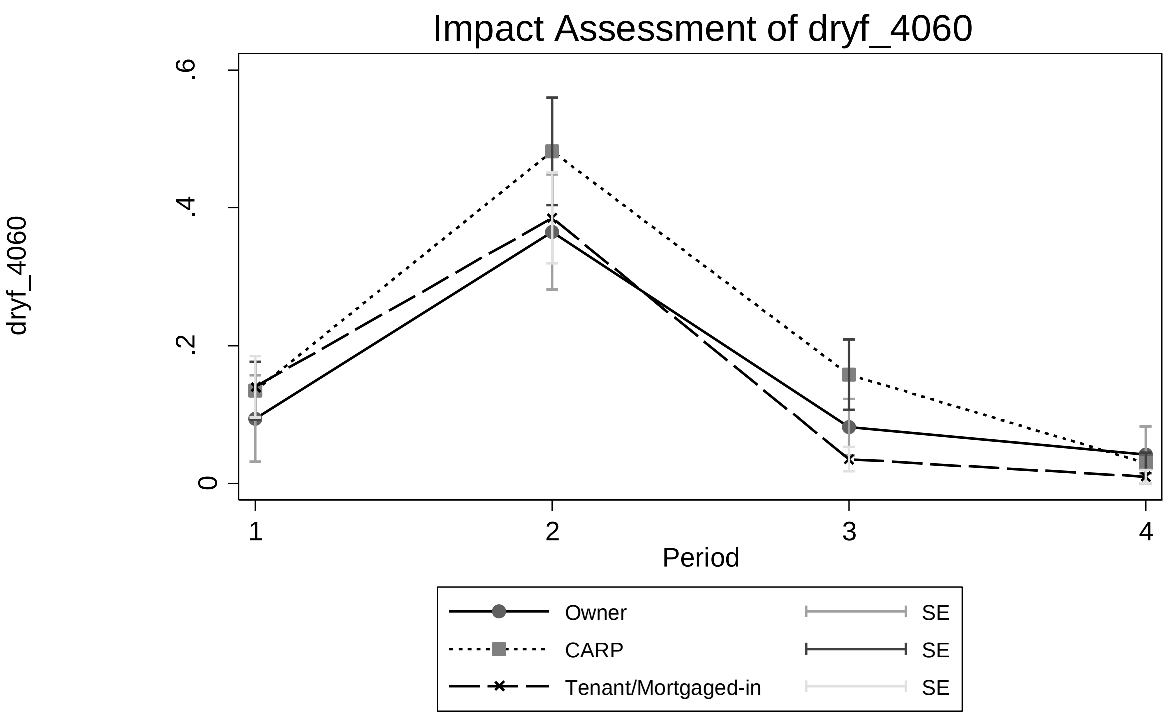
Period	Non rich	Rich	Difference	95% interval		p value
1	15345	17984	-2638	-6083	807	0.13
2	15313	16459	-1146	-4664	2372	0.52
3	21522	24430	-2908	-6774	957	0.14
4	16277	16185	92	-3689	3872	0.96

Figure 65. Household income per capita, by asset holding size, over the survey period.



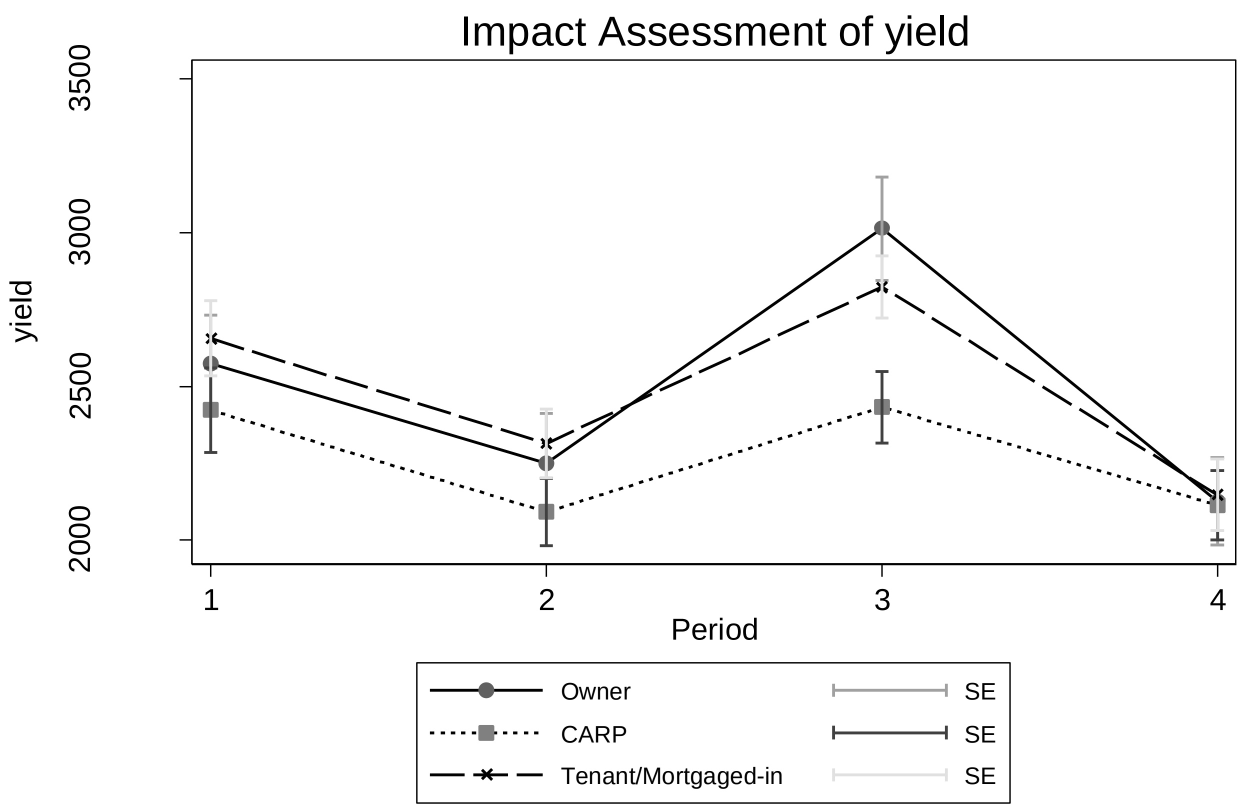
Period	Non rich	Rich	Difference	95% interval		p value
1	4443	11990	-7547	-10317	-4776	0.00
2	6226	13414	-7188	-9895	-4480	0.00
3	8046	18216	-10170	-14307	-6034	0.00
4	7554	14277	-6723	-11356	-2090	0.01

Figure 66. Water stress, by agrarian reform status, over the survey period.



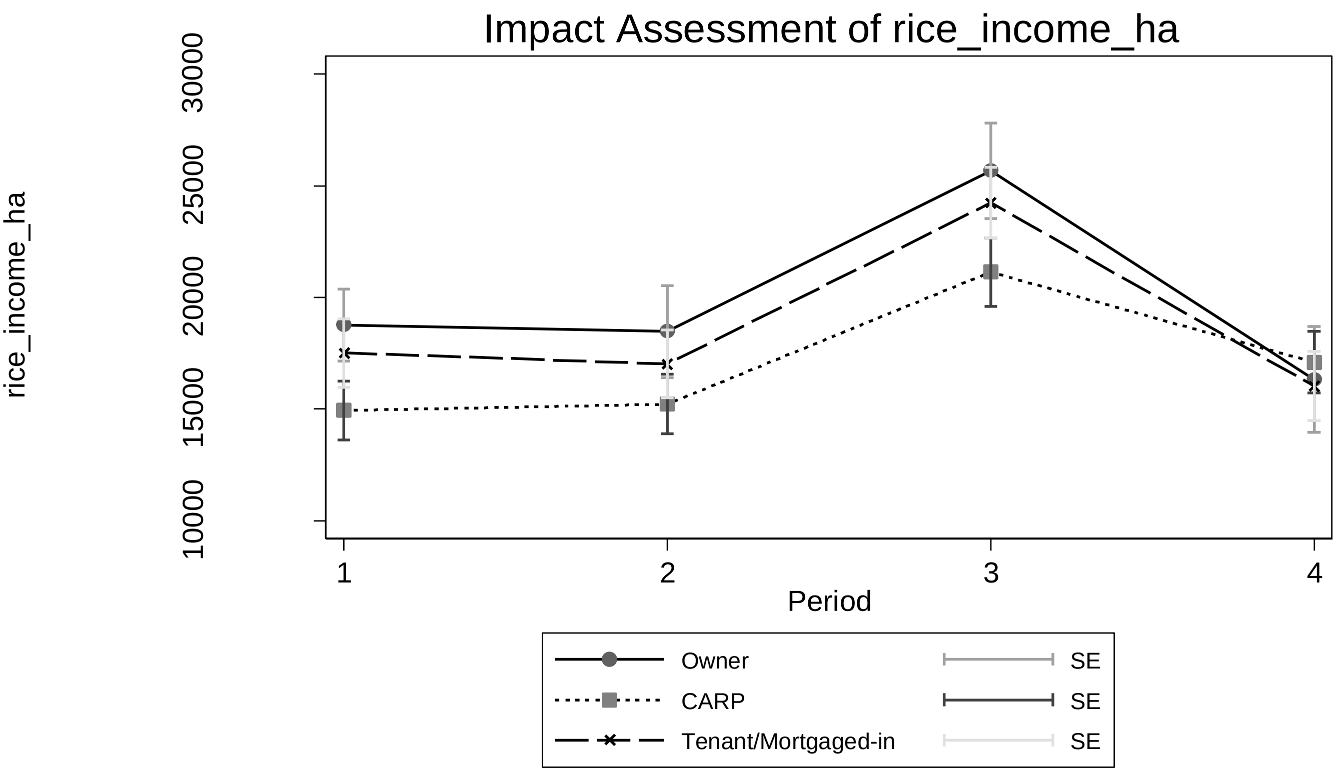
Period	Owner	95% interval		CARP	95% interval		Rent	95% interval		p value
1	0.09	-0.03	0.22	0.13	0.05	0.21	0.14	0.05	0.27	0.82
2	0.36	0.20	0.52	0.48	0.32	063	0.38	0.25	0.51	0.52
3	0.08	0.01	0.16	0.15	0.05	0.25	0.03	0.00	0.06	0.06
4	0.04	-0.39	0.12	0.03	-0.00	0.05	0.01	0.00	0.28	0.44

Figure 67. Rice yield, by agrarian reform status, over the survey period.



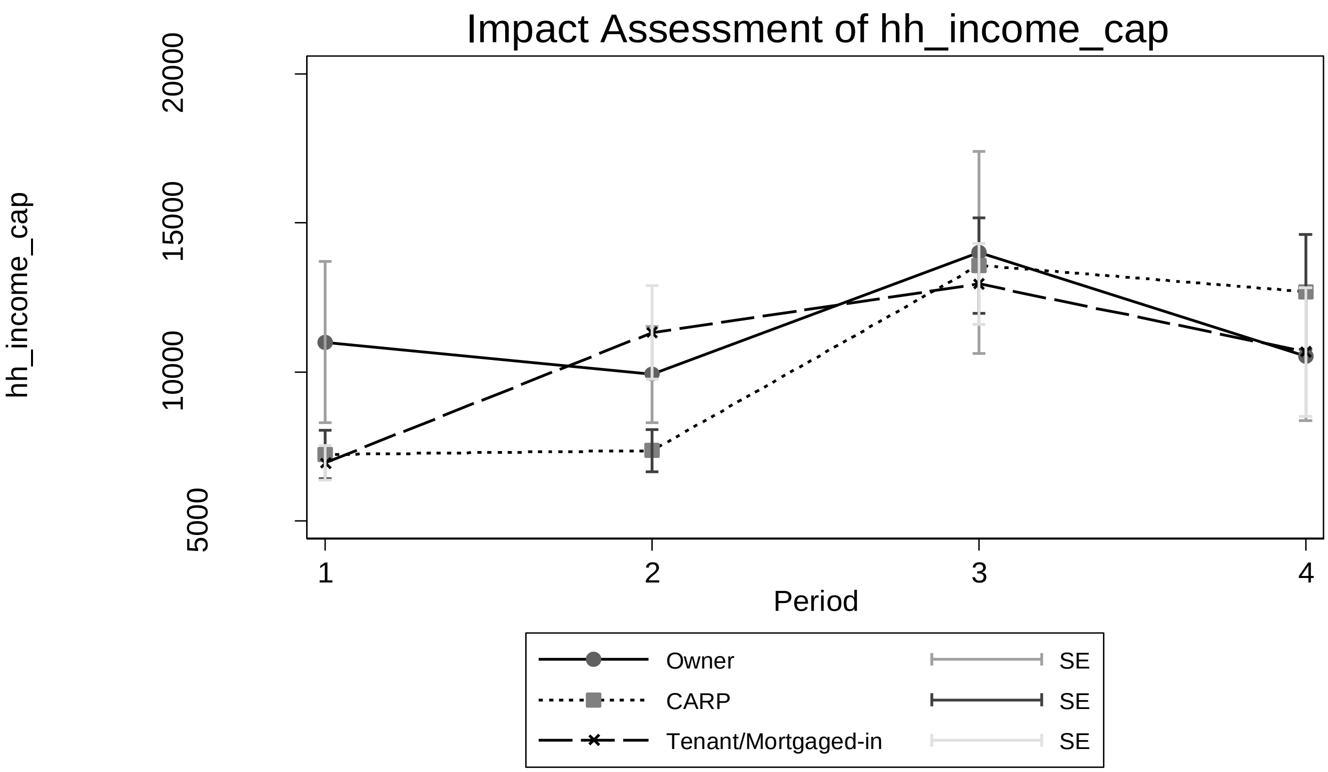
Period	Owner	95% interval		CARP	95% interval		Rent	95% interval		p value
1	2575	2268	2883	2423	2154	2691	2656	2416	2896	0.44
2	2249	1930	2568	2092	1876	2307	2314	2094	2533	0.35
3	3013	2684	3342	2433	2205	2661	2823	2624	3022	0.01
4	2126	1848	2404	2114	1892	2336	2148	1921	2374	0.98

Figure 68. Rice income per hectare, by agrarian reform status, over the survey period.



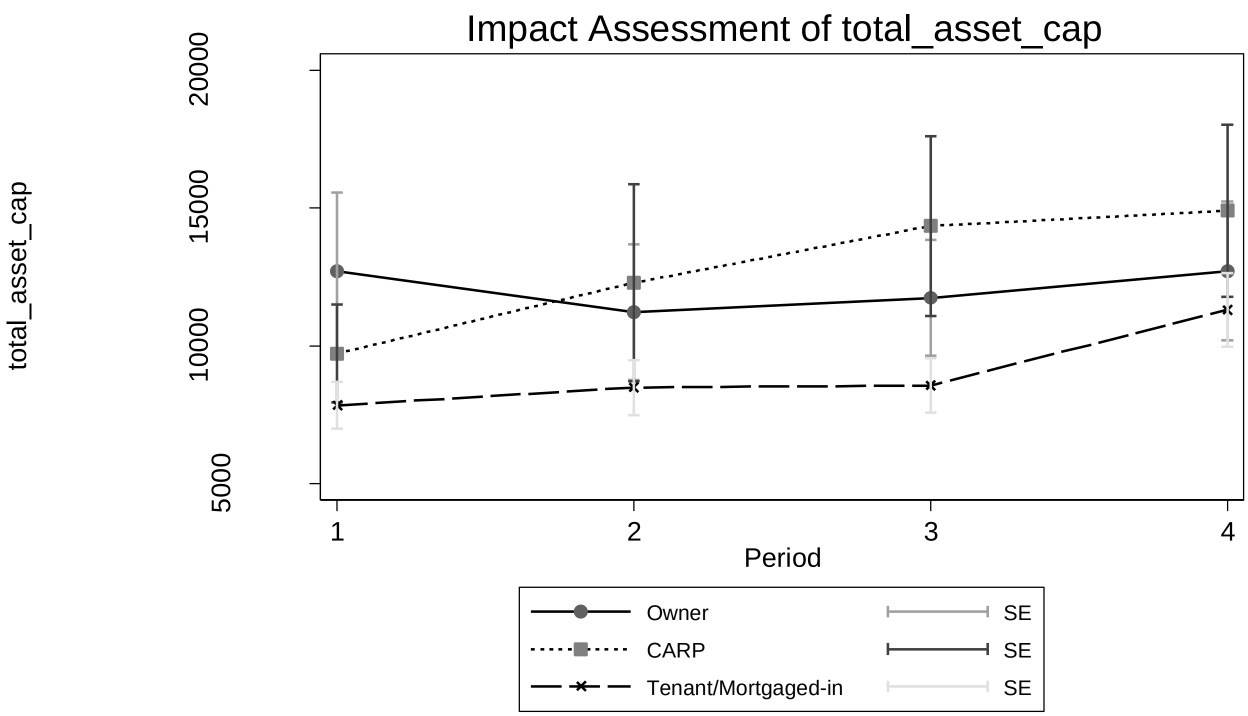
Period	Owner	95% interval		CARP	95% interval		Rent	95% interval		p value
1	18773	15629	21918	14939	12367	17510	17515	14521	20509	0.15
2	18474	14458	22491	15221	12613	17829	17023	14049	19998	0.37
3	25669	21484	29854	21134	18135	24134	24236	21154	27319	0.17
4	16330	11700	20960	17097	14406	19787	16034	12975	19092	0.87

Figure 69. Household income per capita, by agrarian reform status, over the survey period.



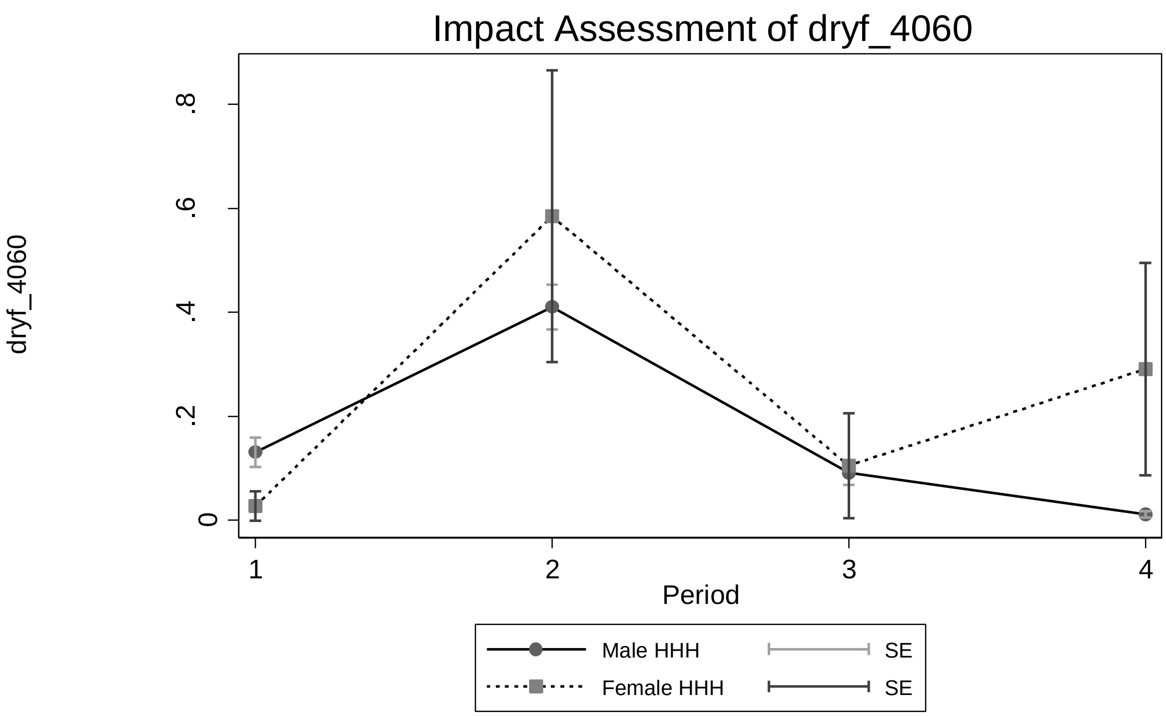
Period	Owner	95% interval		CARP	95% interval		Rent	95% interval		p value
1	11001	5708	16295	7229	5657	8801	6950	5802	8089	0.34
2	9911	6557	13066	7358	5971	8745	11322	8239	14405	0.04
3	14010	7365	20655	13576	10431	16721	12957	10294	15621	0.93
4	10529	6312	14746	12690	8908	16472	10674	6438	14911	0.70

Figure 70. Total asset value per capita, by agrarian reform status, over the survey period.



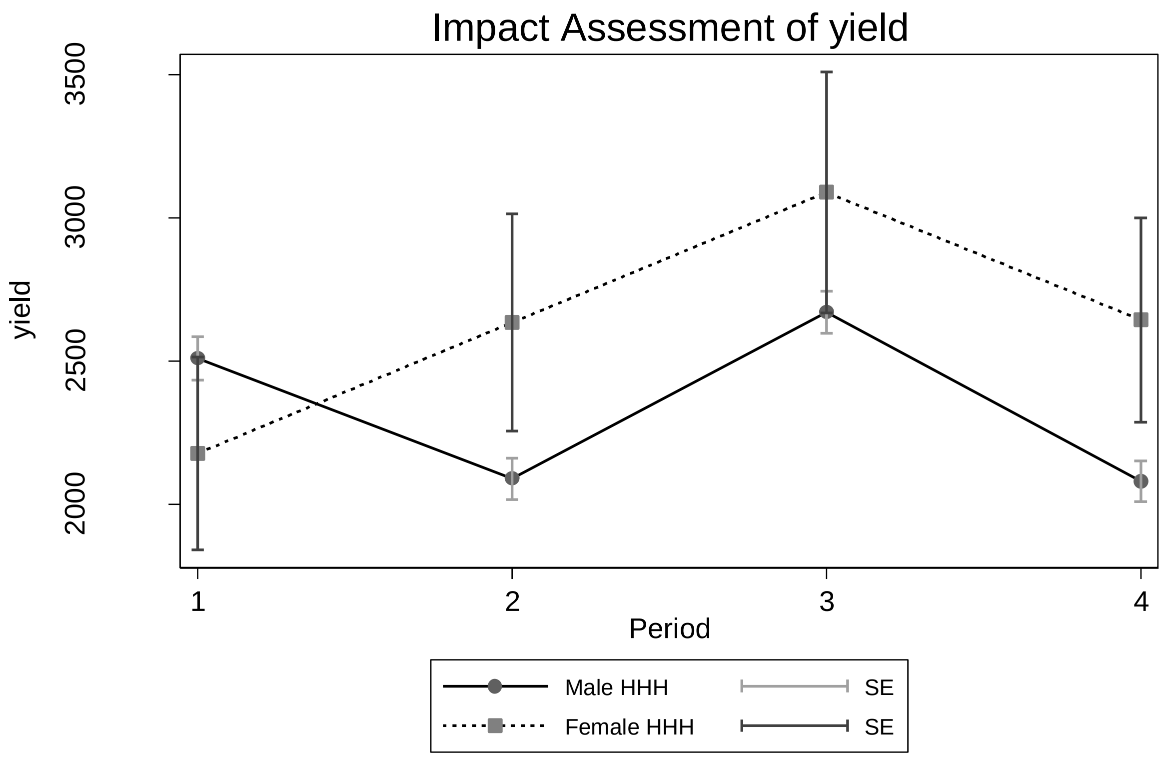
Period	Owner	95% interval		CARP	95% interval		Rent	95% interval		p value
1	12720	7151	18290	9720	6234	13207	7842	6171	9514	0.20
2	11215	6396	16033	12289	5274	19305	8490	6537	10444	0.38
3	11746	7636	15856	14353	7953	20753	8564	6648	10479	0.12
4	12712	7783	17642	14907	8768	21046	11310	8693	13927	0.55

Figure 71. Water stress, by sex of household head, over the survey period.



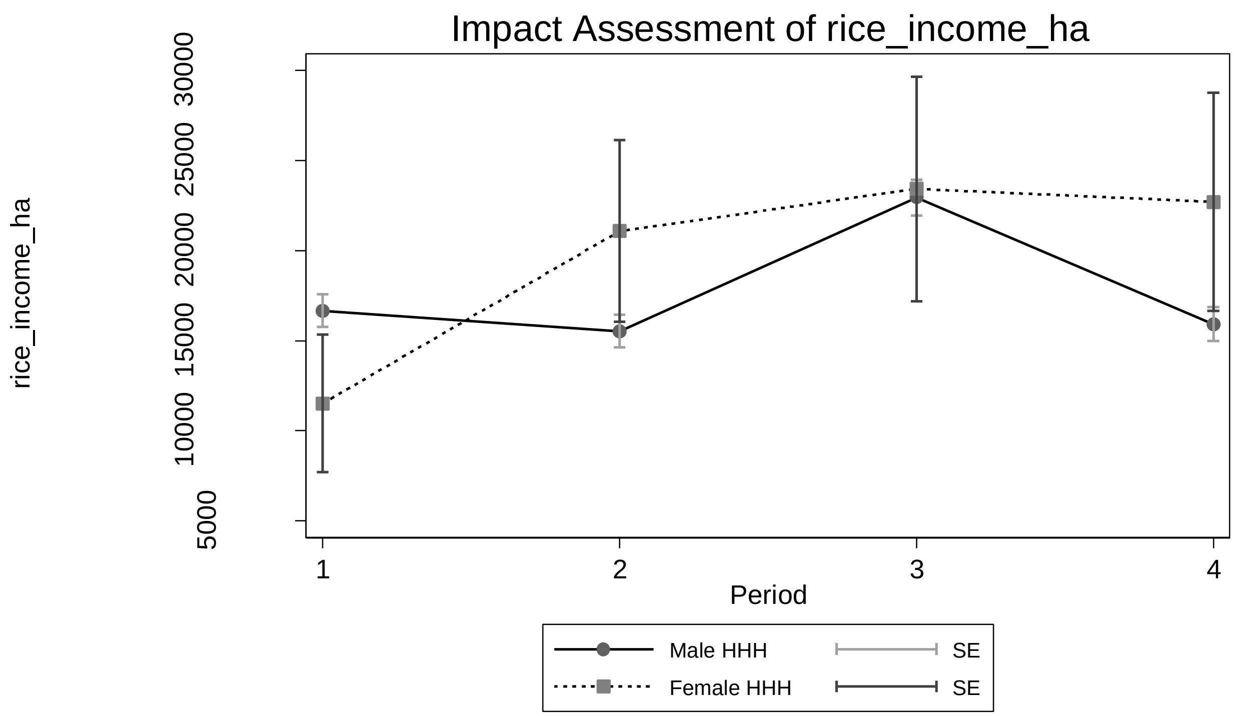
Period	Male HHH	Female HHH	Difference	95% interval		p value
1	0.13	0.03	0.01	0.02	0.18	0.01
2	0.41	0.58	-0.17	-0.71	0.36	0.52
3	0.09	0.10	-0.01	-0.21	0.18	0.88
4	0.11	0.29	-0.27	-0.66	0.10	0.16

Figure 72. Rice yield, by sex of household head, over the survey period.



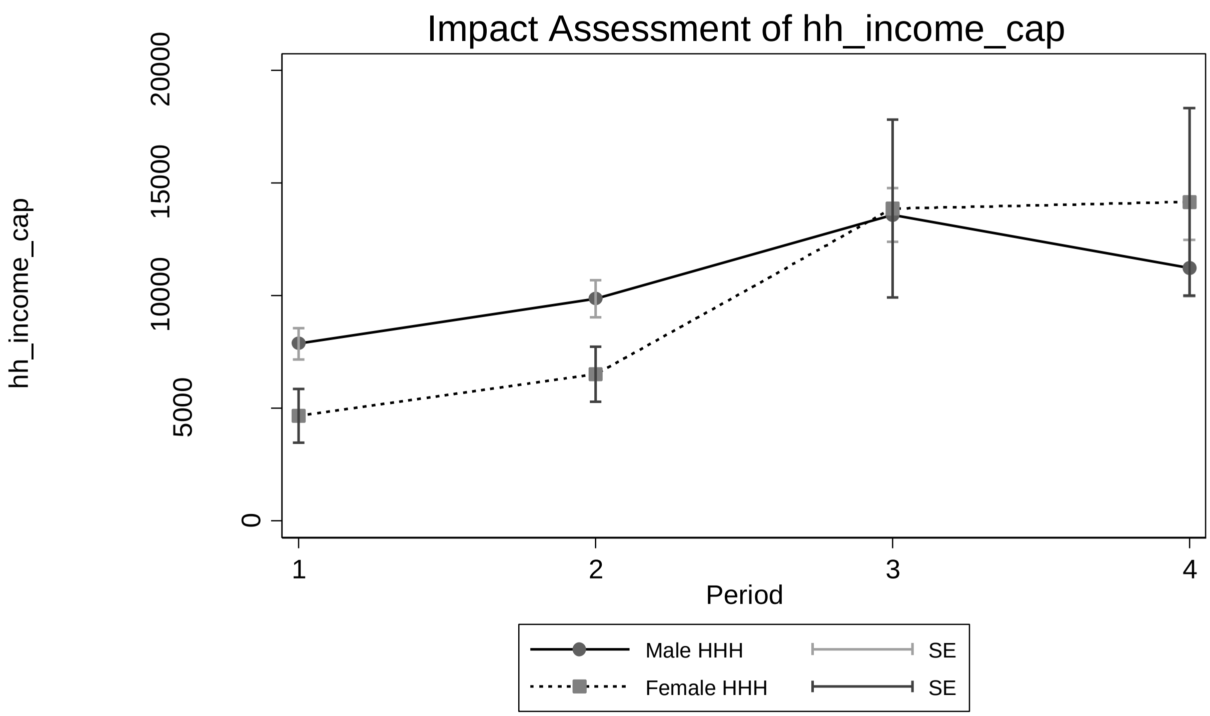
Period	Male HHH	Female HHH	Difference	95% interval		p value
1	2510	2177	333	-330	996	0.33
2	2088	2635	-547	-1283	189	0.15
3	2670	3089	-419	-1236	398	0.31
4	2080	2644	-565	-1258	128	0.11

Figure 73. Rice income per hectare, by sex of household head, over the survey period.



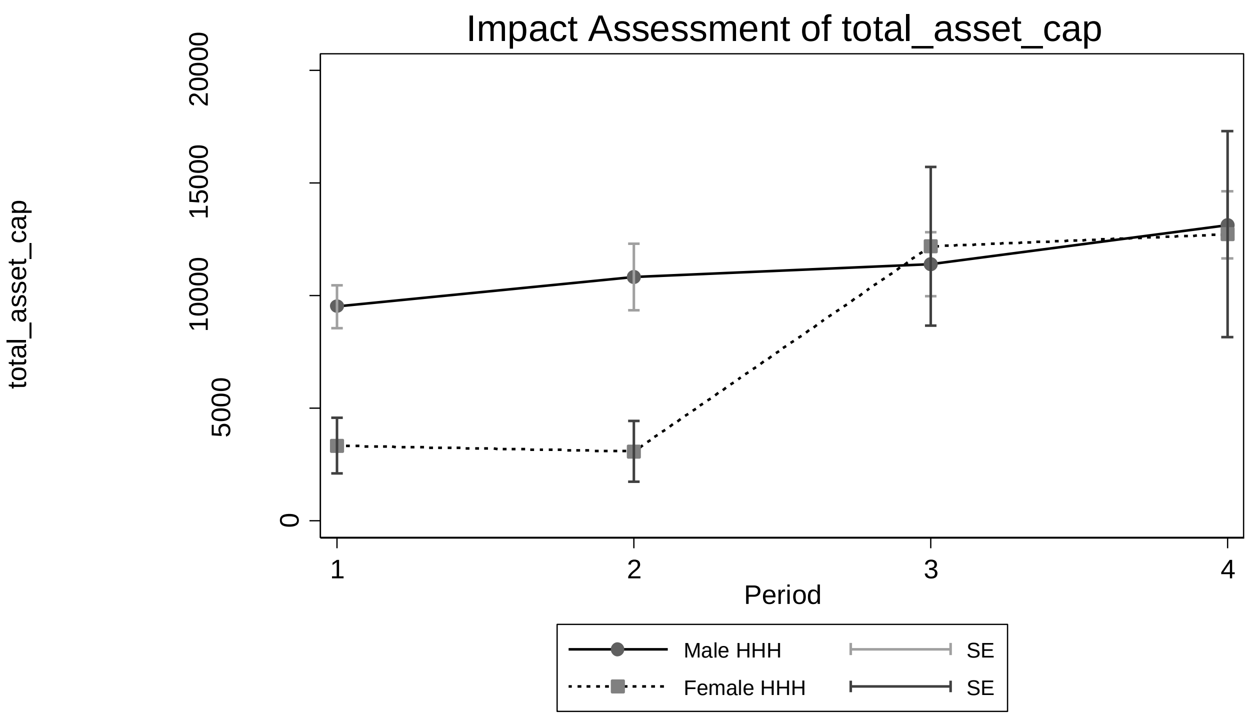
Period	Male HHH	Female HHH	Difference	95% interval		p value
1	16669	11515	5154	-2337	12645	0.18
2	15534	21083	-5549	-15280	4182	0.26
3	22952	23421	-469	-12512	11575	0.94
4	15924	22704	-6780	-18420	4859	0.25

Figure 74. Household income per capita, by sex of household head, over the survey period.



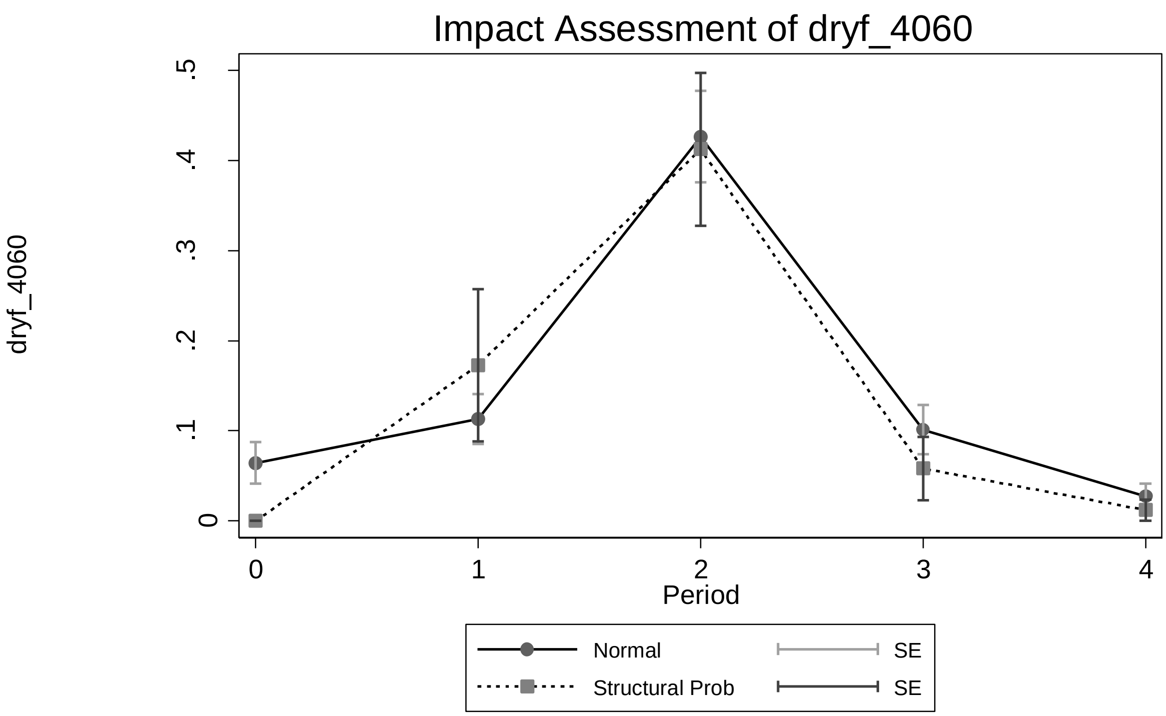
Period	Male HHH	Female HHH	Difference	95% interval		p value
1	7867	4667	3200	541	5859	0.02
2	9863	6512	3351	516	6187	0.02
3	13580	13868	-288	-8199	7622	0.94
4	11221	14163	-2942	-11237	5354	0.49

Figure 75. Total asset value per capita, by sex of household head, over the survey period.



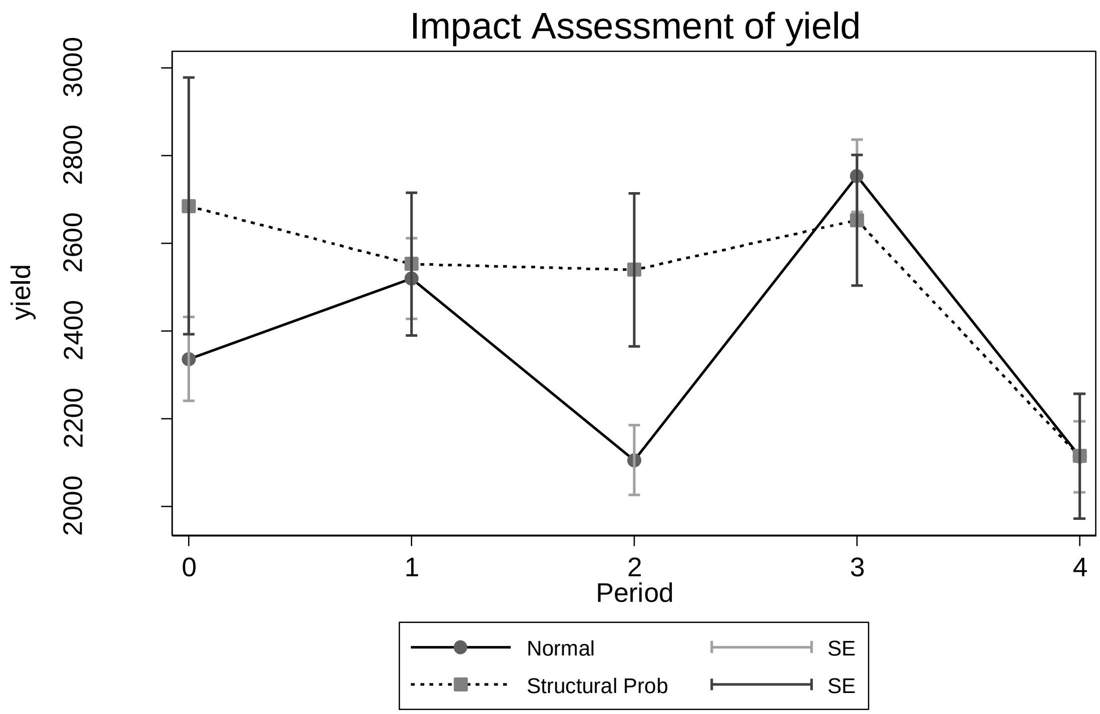
Period	Male HHH	Female HHH	Difference	95% interval		p value
1	9512	3338	6174	3147	9200	0.00
2	10827	3086	7742	3848	11635	0.00
3	11385	12187	-801	-8098	6495	0.83
4	13140	12720	420	-8753	9593	0.93

Figure 76. Water stress, by structural problem of TSA, over the survey period.



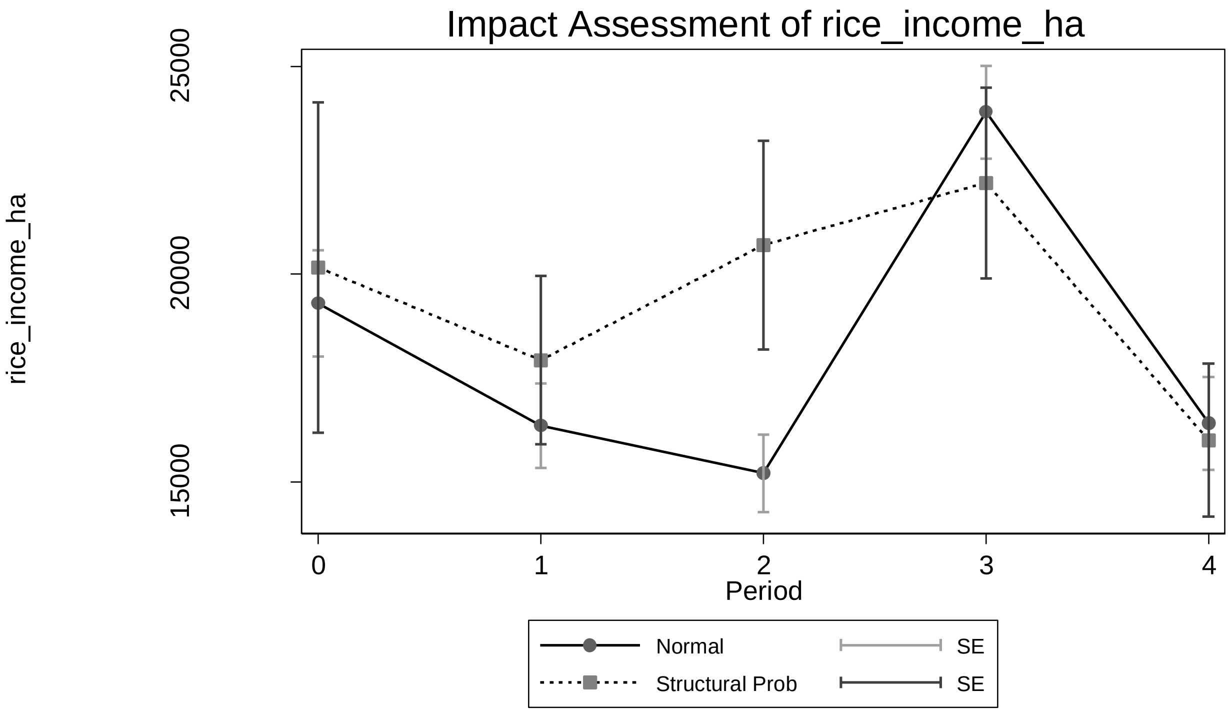
Period	Normal	Structural problem	Difference	95% interval		p value
1	0.11	0.17	-0.06	-0.22	0.11	0.50
2	0.43	0.41	0.02	-0.17	0.21	0.88
3	0.10	0.06	0.04	-0.04	0.13	0.33
4	0.02	0.01	0.01	-0.02	0.05	0.85

Figure 77. Rice yield, by structural problem of TSA, over the survey period.



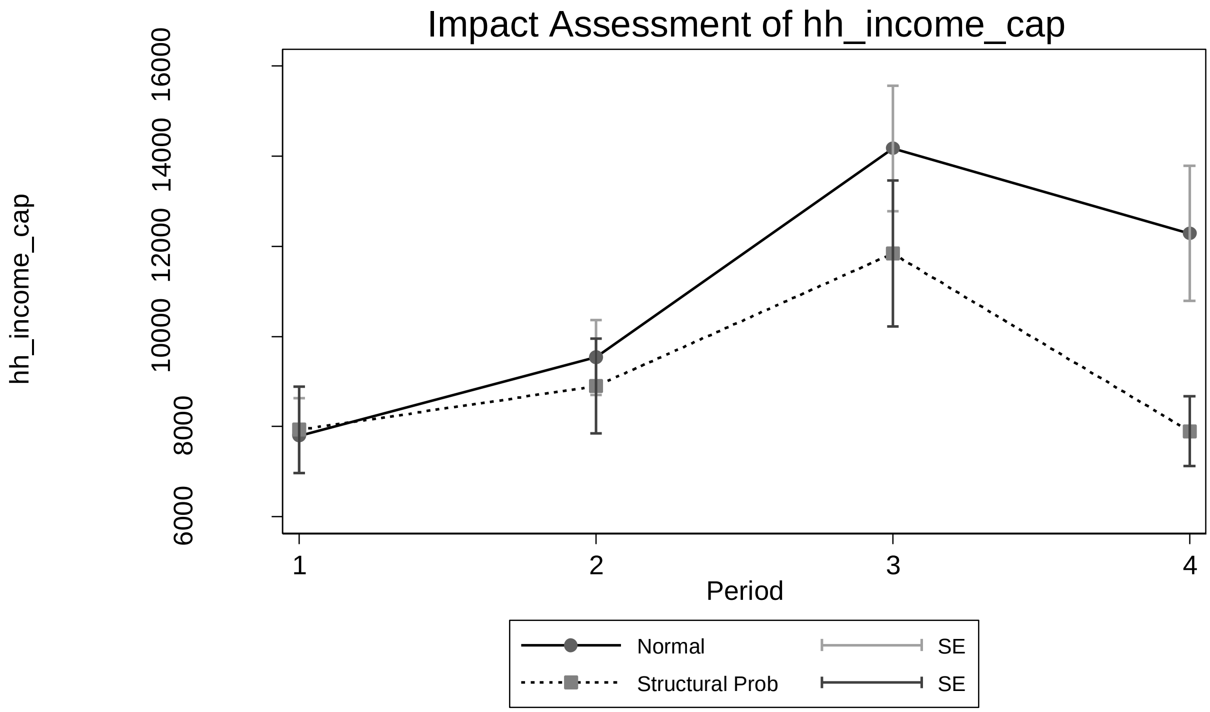
Period	Normal	Structural problem	Difference	95% interval		p value
1	2519	2553	-33	-399	332	0.85
2	2106	2539	-433	-809	-57	0.02
3	2753	2653	100	-232	434	0.55
4	2114	2115	-1	322	320	0.99

Figure 78. Rice income, by structural problem of TSA, over the survey period.



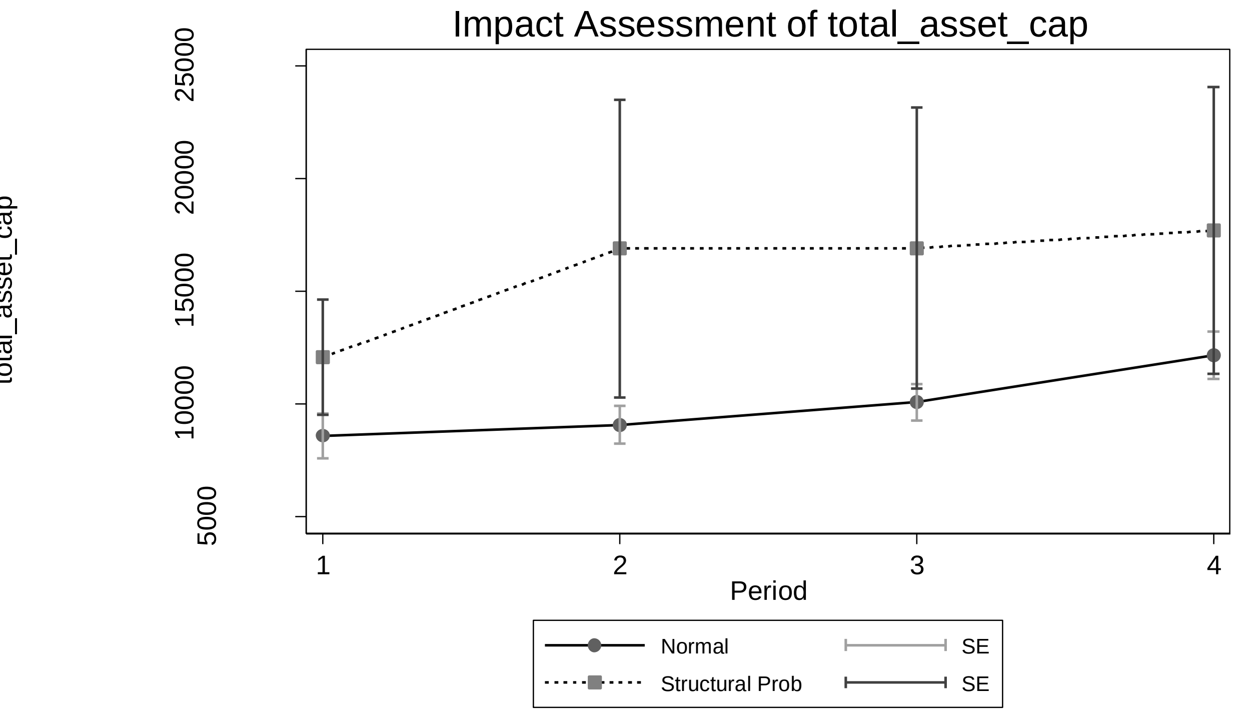
Period	Normal	Structural problem	Difference	95% interval		p value
1	16354	17929	-1575	-6015	2865	0.48
2	15212	20700	-5488	-10729	-248	0.04
3	23894	22197	1697	-3299	6694	0.50
4	16411	16005	406	-3812	4624	0.85

Figure 79. Household income, by structural problem of TSA, over the survey period.



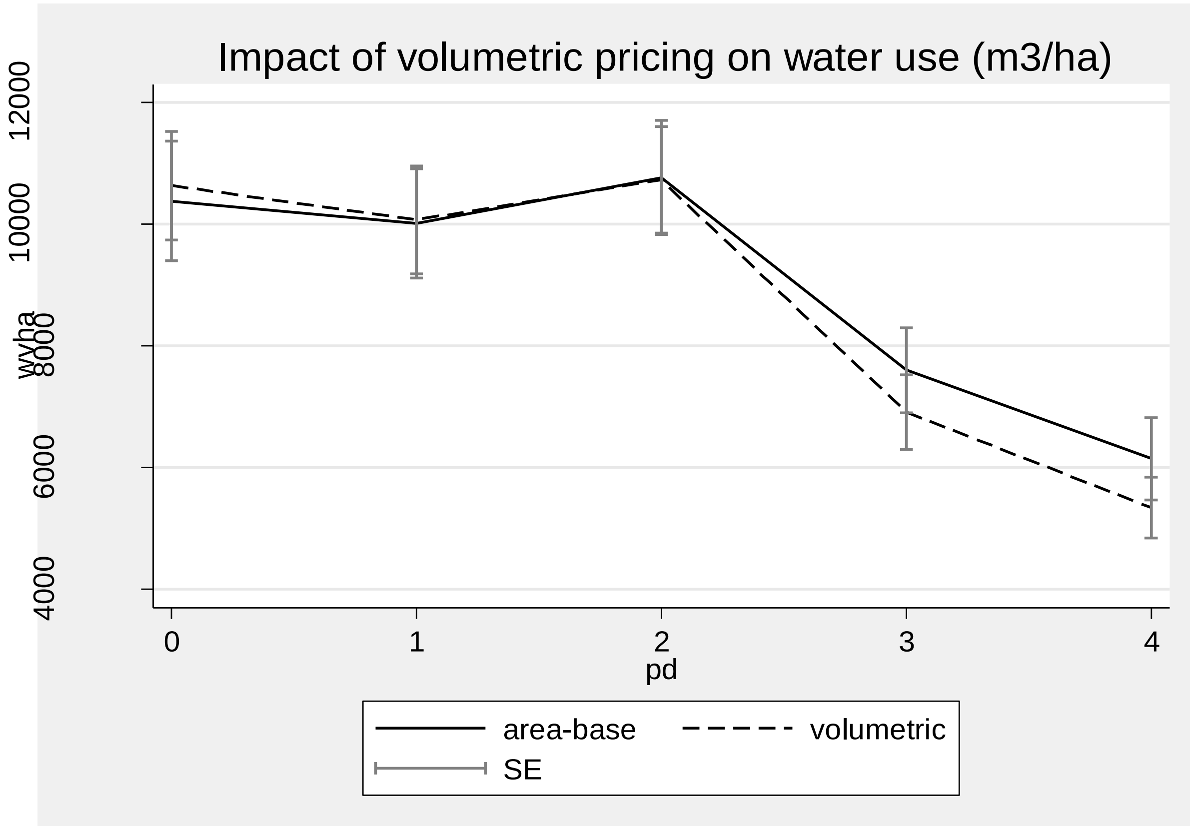
Period	Normal	Structural problem	Difference	95% interval		p value
1	7798	7929	-130	-2625	2364	0.91
2	9537	8896	641	-1986	3269	0.63
3	14169	11838	2330	-1871	6532	0.27
4	12285	7896	4388	1066	7710	0.01

Figure 80. Total asset value, by structural problem of TSA, over the survey period.



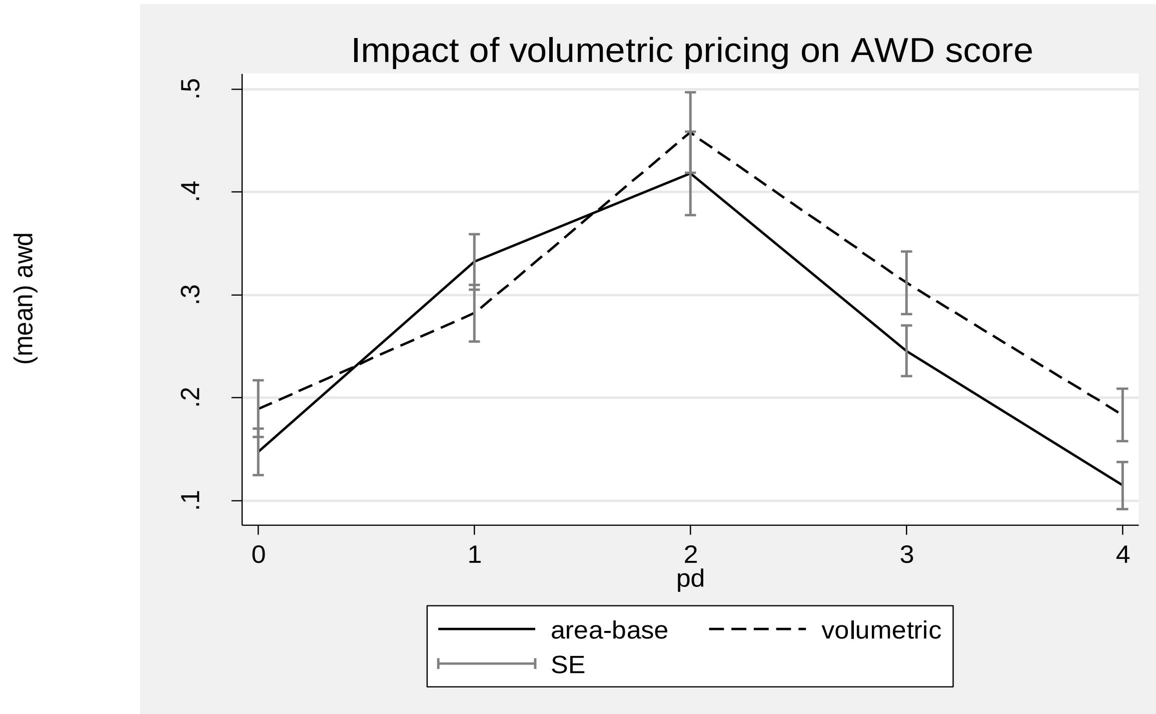
Period	Normal	Structural problem	Difference	95% interval		p value
1	8592	12070	-3478	-8849	1893	0.20
2	9072	16895	-7823	-20838	5192	0.23
3	10078	16912	-6833	-19153	5485	0.27
4	12162	17697	-5534	-18164	7094	0.39

Figure 81. TSA-level water use, by pricing system, over the survey period.



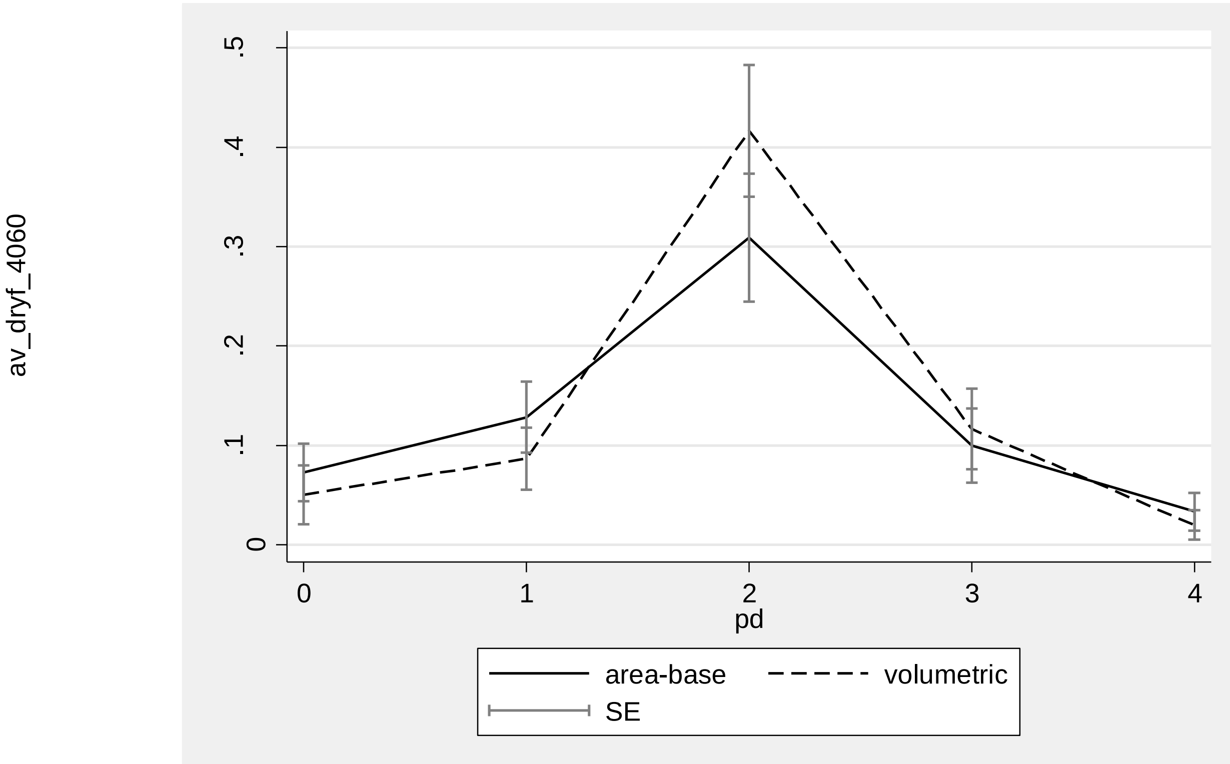
Period	Area-based	Volumetric	Combined	Difference	95% interval		p value
0	10381	10633	10505	-252	-2898	2393	0.85
1	10012	10072	10042	-60	-2579	2458	0.96
2	10764	10727	10745	37	-2504	2579	0.98
3	7599	6913	7253	686	-1155	2526	0.46
4	6148	5342	5741	806	-855	2467	0.34

Figure 82. TSA-level average AWD score, by pricing system, over the survey period.



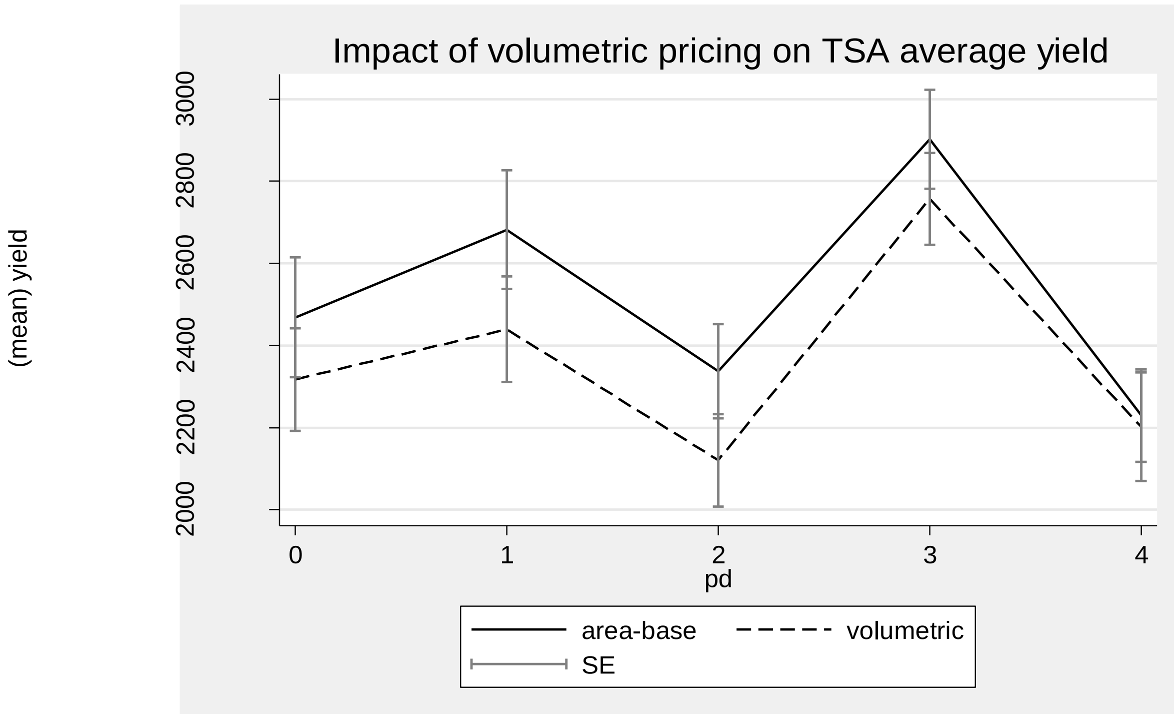
Period	Area-based	Volumetric	Combined	Difference	95% interval		p value
0	0.147	0.189	0.169	-0.042	-0.114	0.029	0.24
1	0.332	0.282	0.306	0.050	-0.027	0.127	0.20
2	0.418	0.458	0.439	-0.040	-0.151	0.072	0.48
3	0.246	0.312	0.28	-0.066	-0.144	0.012	0.10
4	0.115	0.184	0.15	-0.069	-0.138	0.000	0.05

Figure 83. TSA-level water stress, by pricing system, over the survey period



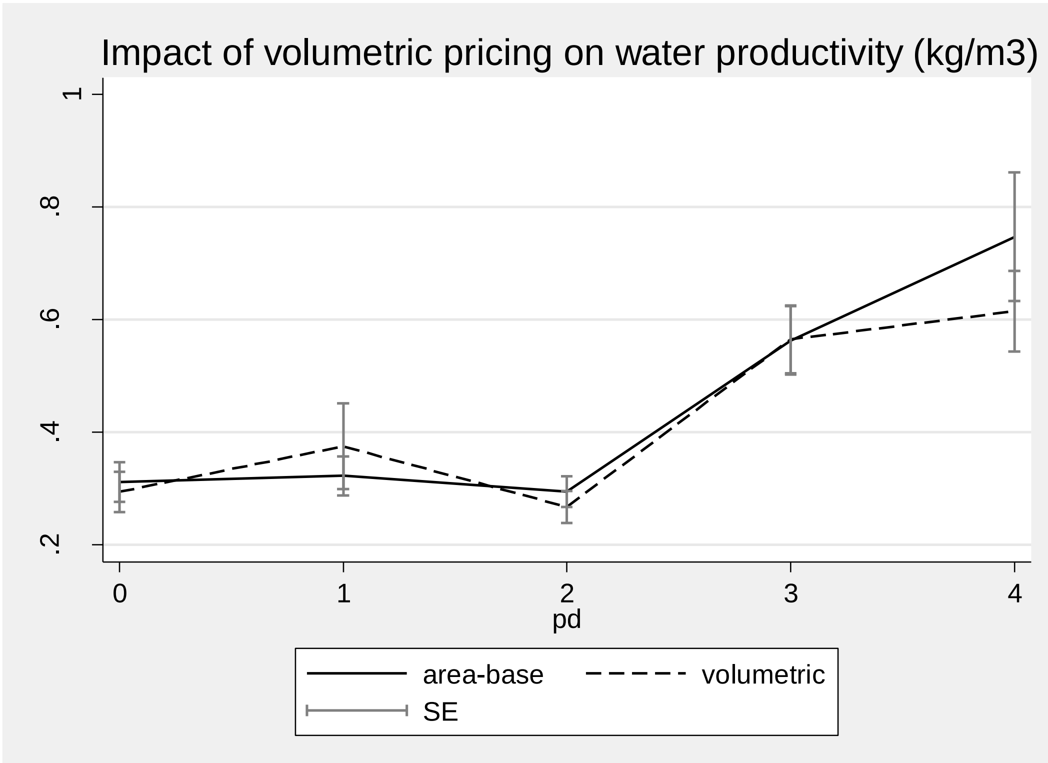
Period	Area-based	Volumetric	Combined	Difference	95% interval		p value
0	0.07	0.05	0.60	0.02	-0.06	0.10	0.59
1	0.12	0.09	0.10	0.03	-0.06	0.12	0.48
2	0.33	0.45	0.39	-0.11	-0.29	0.07	0.21
3	0.09	0.10	0.10	-0.01	-0.11	0.09	0.84
4	0.03	0.02	0.02	0.01	-0.03	0.06	0.55

Figure 84. TSA-level average yield, by pricing system, over the survey period.



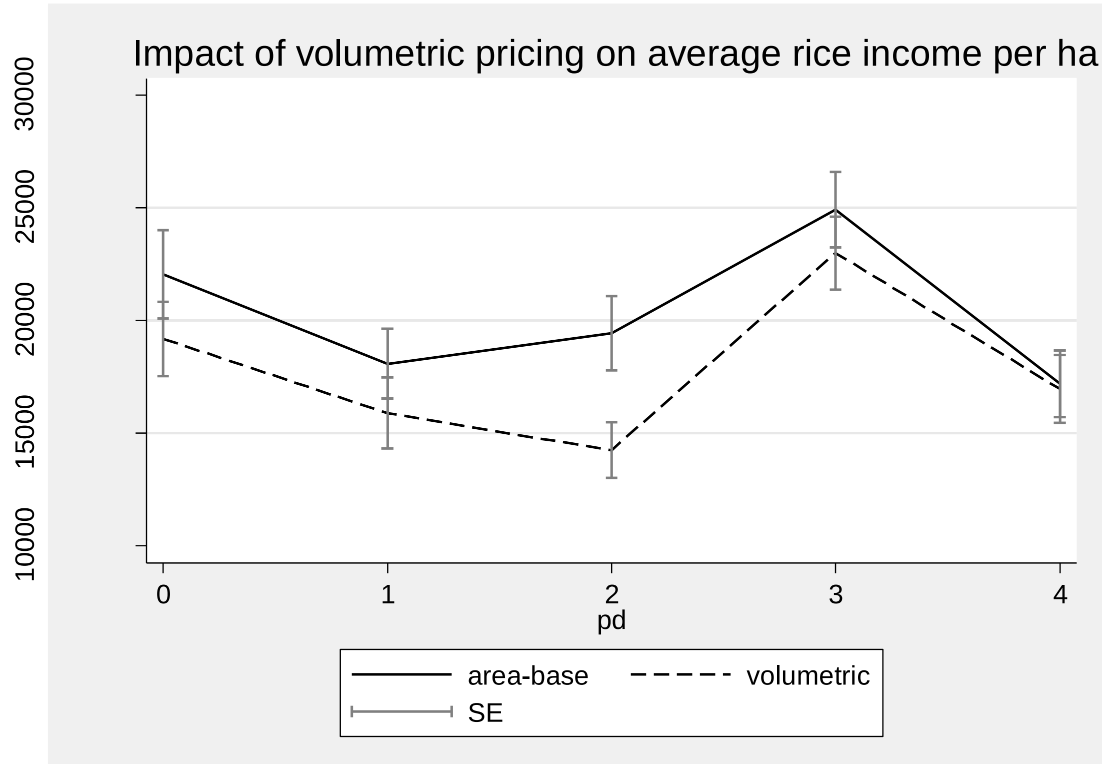
Period	Area-based	Volumetric	Combined	Difference	95% interval		p value
0	2489	2278	2382	212	-170	593	0.27
1	2655	2399	2521	255	-111	621	0.17
2	2310	2050	2174	260	-54	574	0.10
3	2850	2702	2774	148	-170	467	0.36
4	2192	2145	2168	47	-287	382	0.78

Figure 85. TSA-level average water productivity, by pricing system, over the survey period.



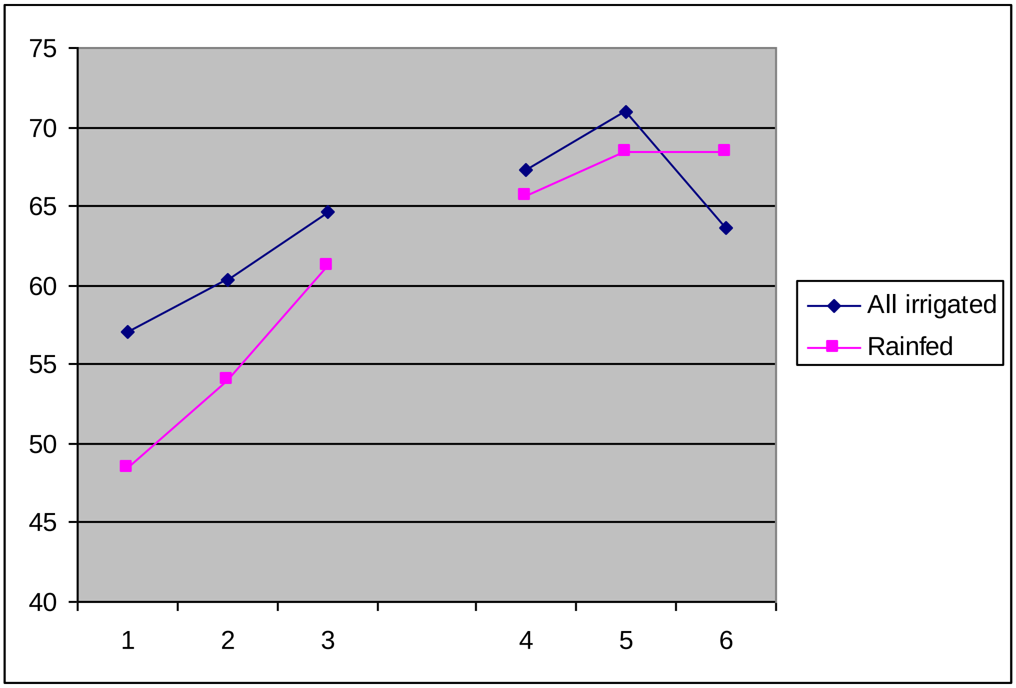
Period	Area-based	Volumetric	Combined	Difference	95% interval		p value
0	0.339	0.370	0.355	-0.031	-0.199	-0.137	0.71
1	0.300	0.326	0.313	-0.027	-0.180	-0.127	0.73
2	0.563	0.565	0.564	-0.002	-0.172	0.168	0.98
3	0.731	0.657	0.694	0.074	-0.201	0.348	0.60
4	0.325	0.288	0.306	0.037	-0.066	0.139	0.48

Figure 86. TSA-level average rice income per hectare, by pricing system, over the survey period.



Period	Area-based	Volumetric	Combined	Difference	95% interval		p value
0	22415	18806	20584	3610	-1437	8657	0.16
1	17781	15611	16644	2169	-2029	6368	0.31
2	19053	13549	16170	5504	1577	9430	0.01
3	24450	22579	16644	2169	-2561	6304	0.40
4	16830	16682	16754	148	-3848	4143	0.94

Figure 87. Mean contribution over six rounds of public goods game in irrigated and rainfed areas.



Appendix Tables

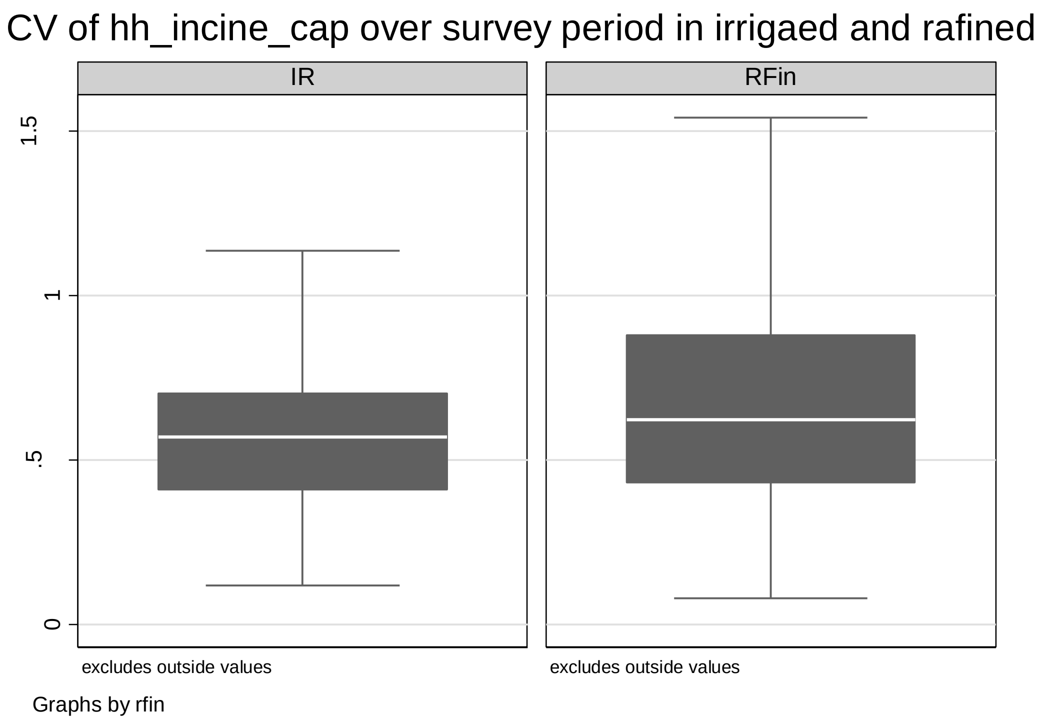
A1: Mean differences in landholding, asset position, owner cultivator proportion, and female-headed household proportion.

	Landholdings	Asset position	Tenure (prop of CARP cultivator)	Gender	Structural problem
Lateral					
Lateral –up	1.12	12981	0.39	0.03	0.21
	(0.06)	(1743)	(0.03)	(0.02)	(0.00)
Lateral – down	1.30	14033	0.36	0.06	0.12
	(0.10)	(1888)	(0.03)	(0.01)	(0.00)
Diff	-0.17	-1051	0.03	-0.02	0.08***
	(0.11)	(2570)	(0.04)	(0.03)	(0.00)
TSA					
TSA – up	1.21	14413	0.41	0.05	na
	(0.76)	(2188)	(0.03)	(0.02)	
TSA – mid	1.21	10304	0.33	0.08	na
	(0.08)	(1270)	(0.06)	(0.04)	
TSA -- down	1.07	13077	0.34	0.005	na
	(0.07)	(1835)	(0.05)	(0.005)	
F value(H0: all means are equal)	1.14	1.64	1.10	4.86***	na

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

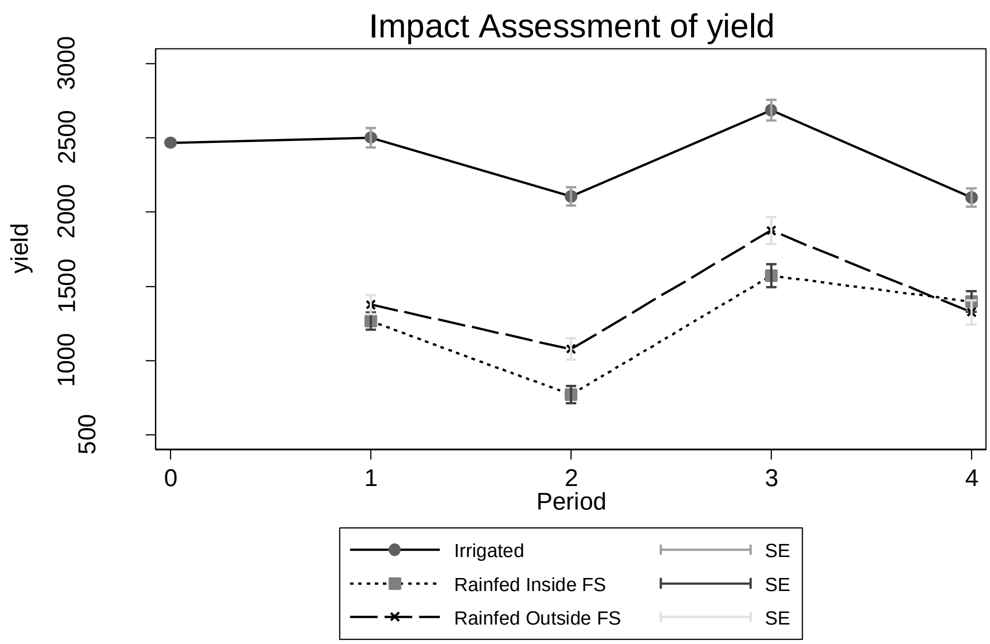
Appendix Figures

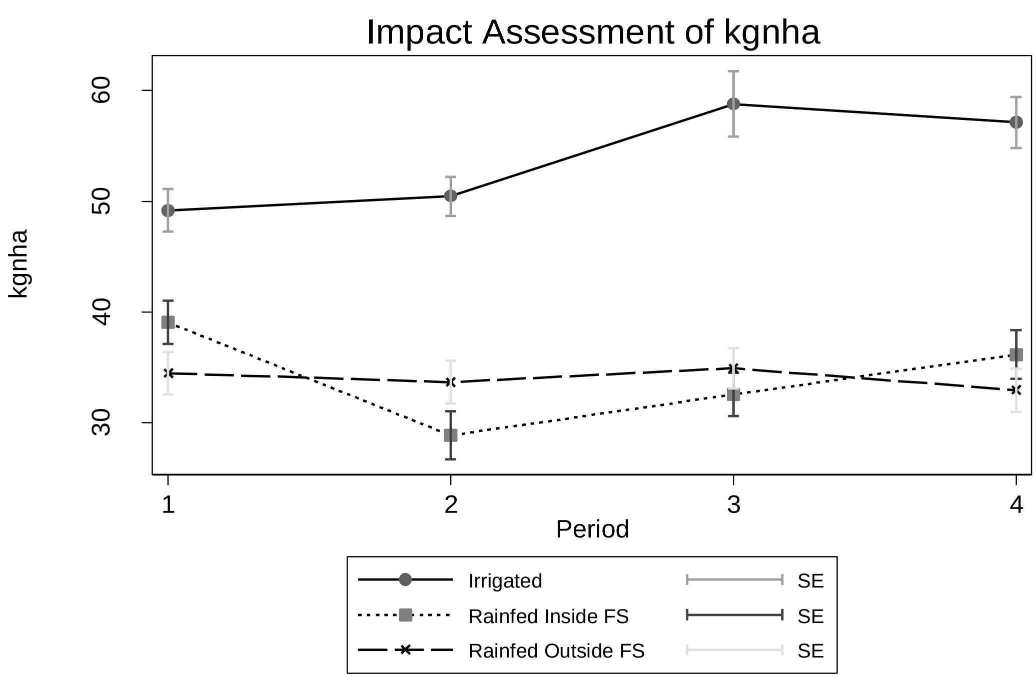
Figure A1. Coefficient of variation of household income over the survey period in irrigated and rainfed areas.

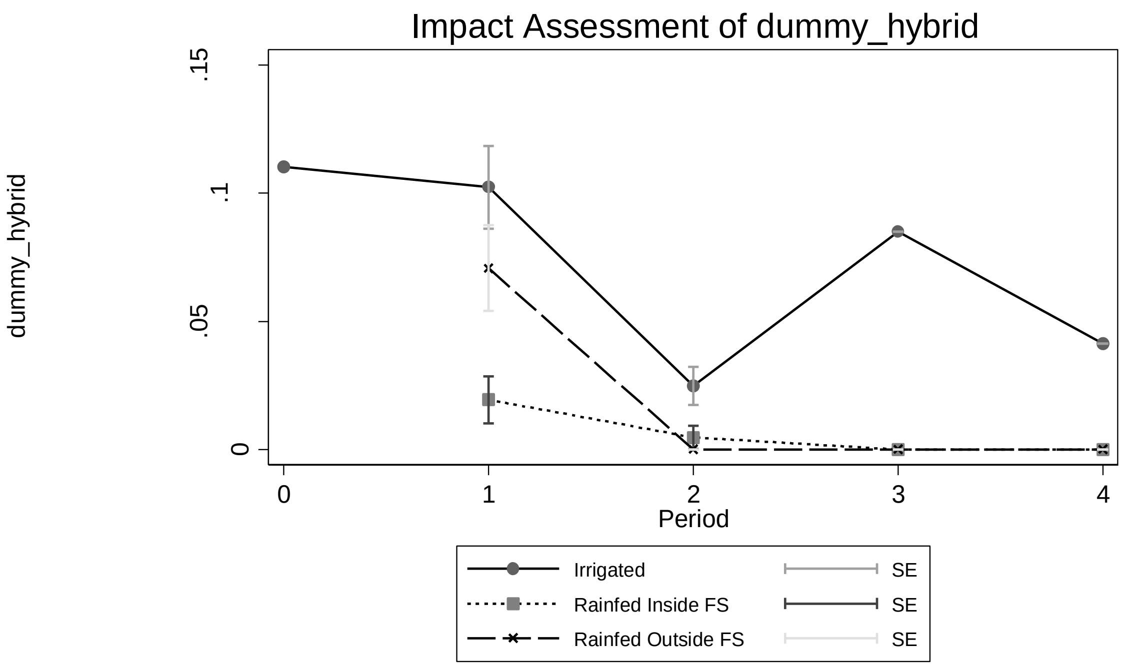


<u>Appendix figures correspond to Figures 16 – 30.</u>

Comparison between irrigated and rainfed area, including rainfed area not covered by the feasibility studies.



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2
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4
Period
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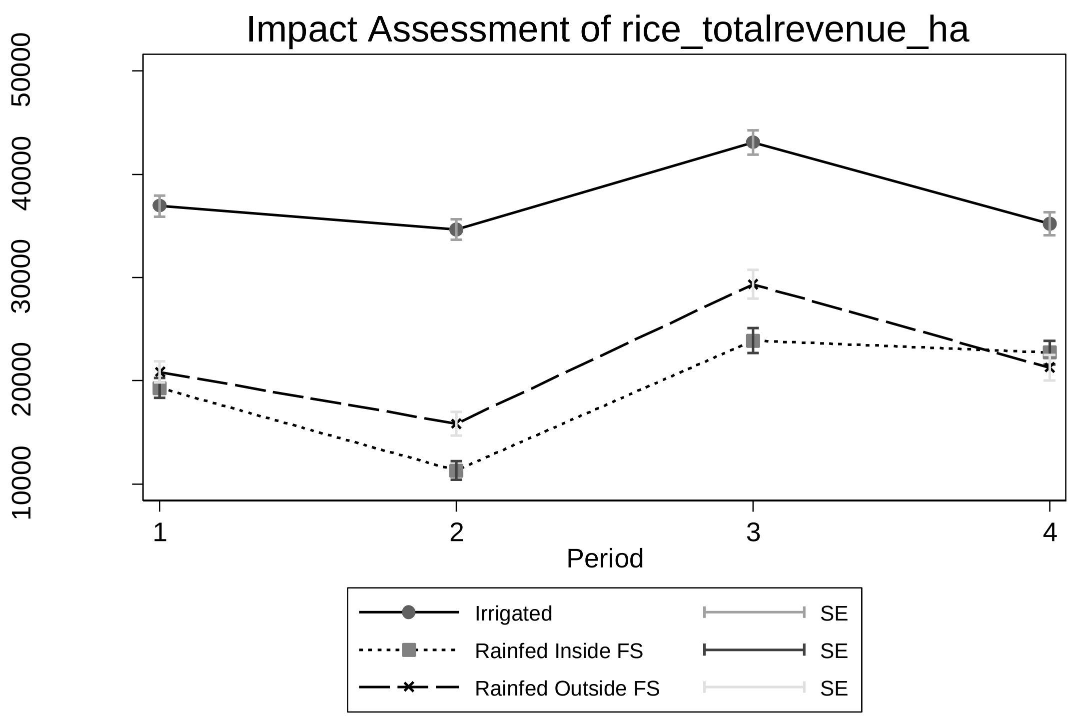
SE
Rainfed Outside FS
SE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50000
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2
3
4
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Irrigated
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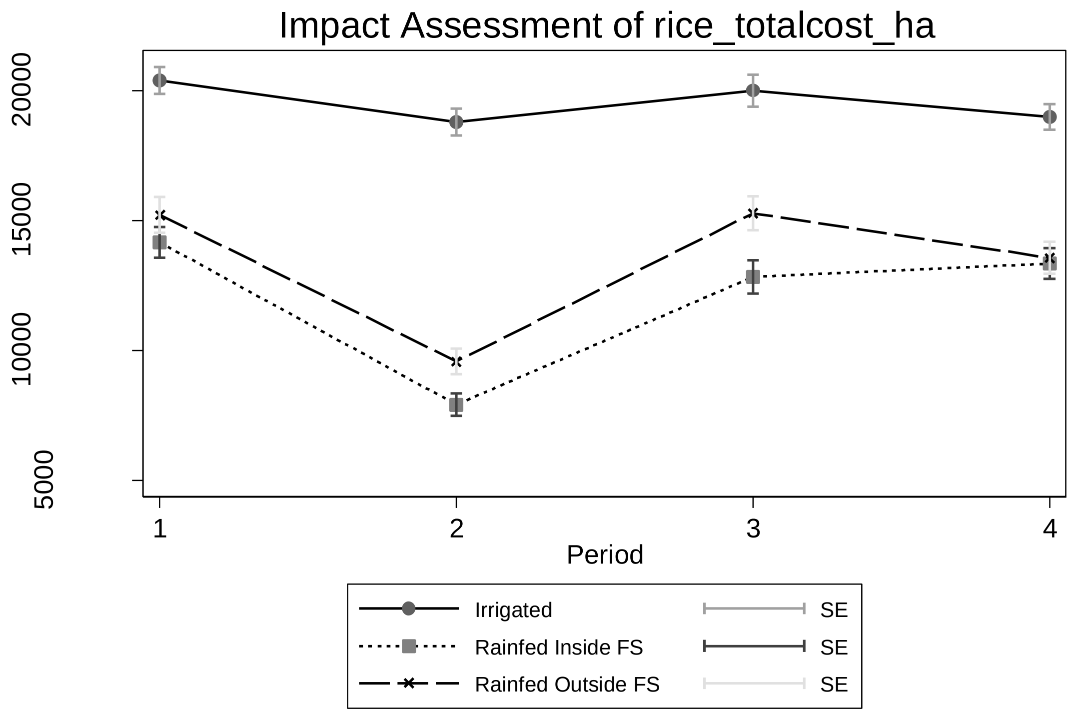
Rainfed Inside FS
SE
Rainfed Outside FS
SE


Impact Assessment of rice_totalcost_ha
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2
3
4
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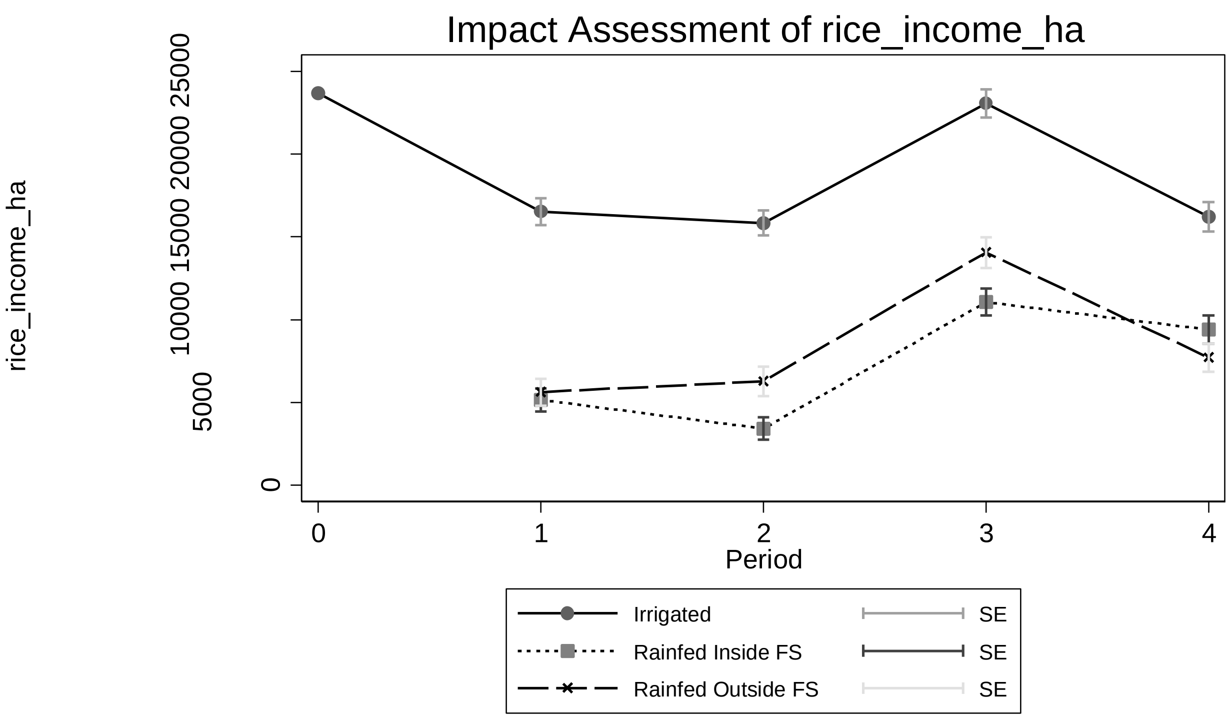
Irrigated
Rainfed Inside FS
Rainfed Outside FS
SE
SE
SE


Impact Assessment of rice_income_ha
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Irrigated
Rainfed Inside FS
Rainfed Outside FS
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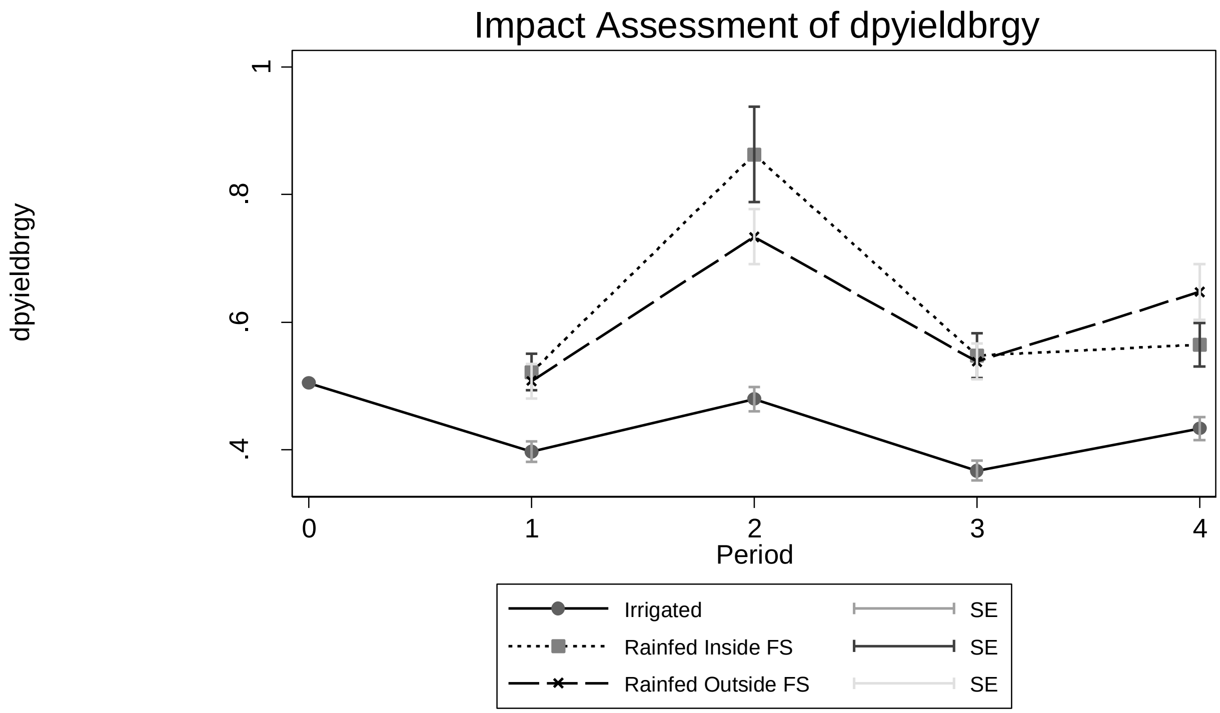
SE
SE


Impact Assessment of dpyieldbrgy
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0
1
2
3
4
Period
Irrigated
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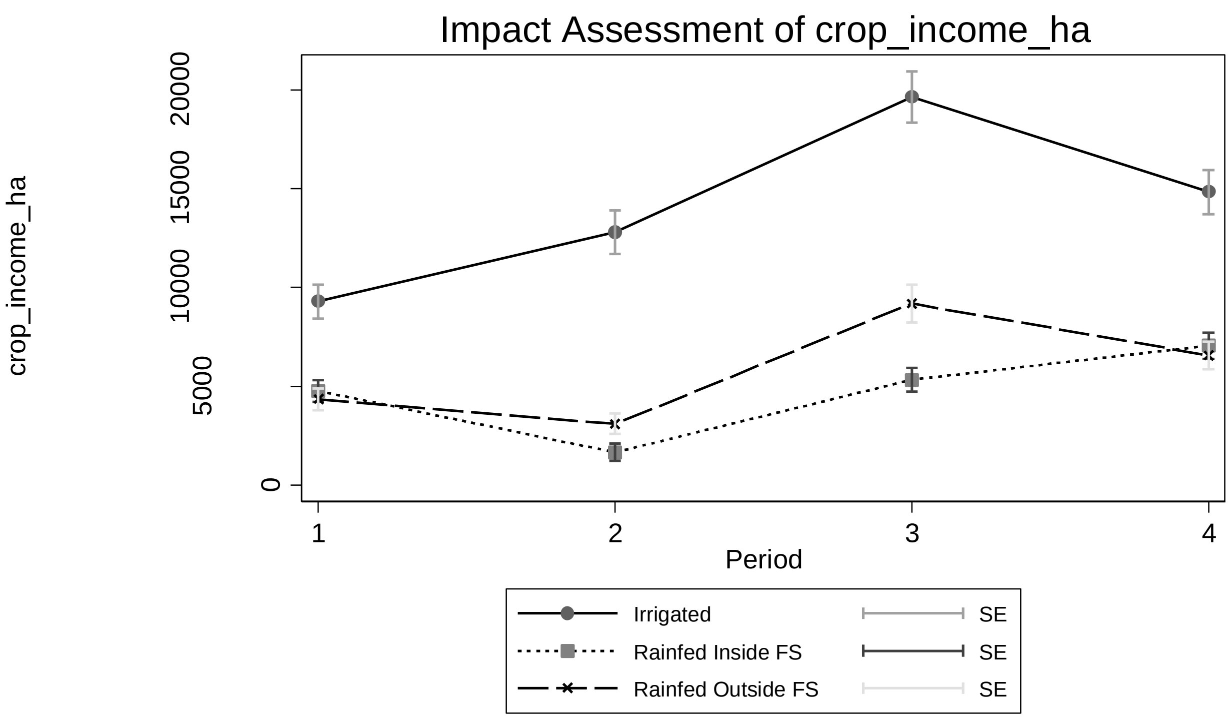
Rainfed Inside FS
SE
Rainfed Outside FS
SE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15000
20000
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4
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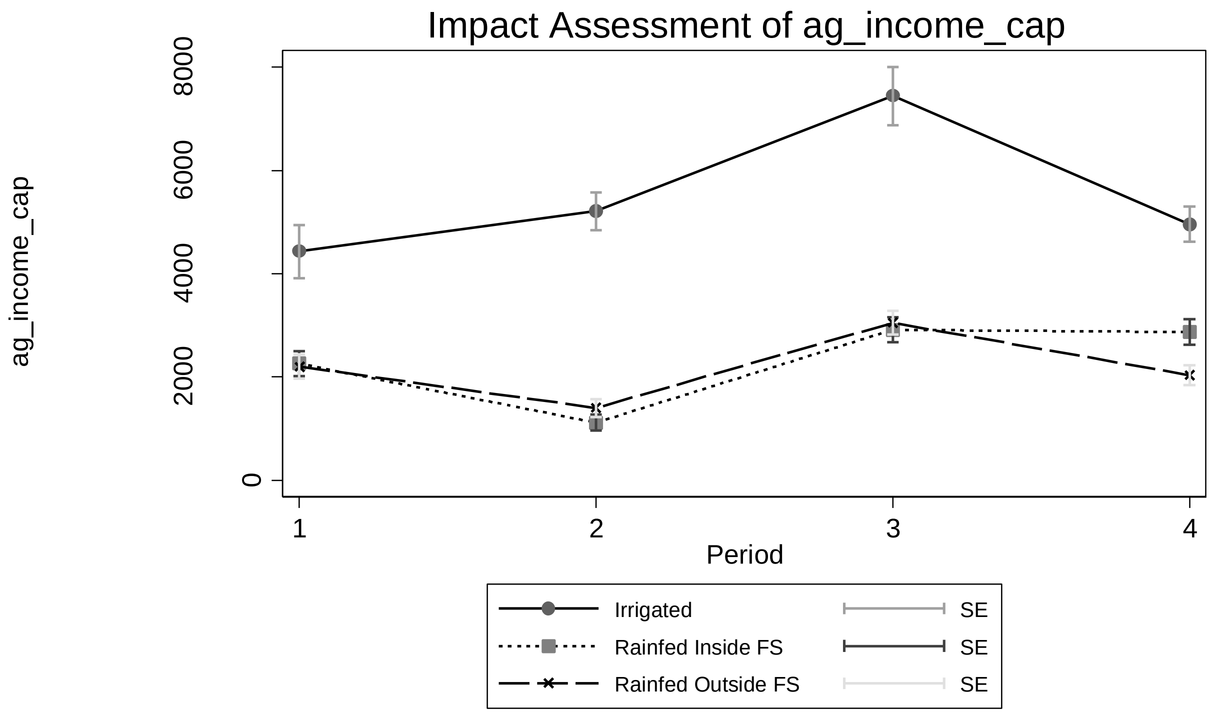
SE
Rainfed Outside FS
SE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6000
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2
3
4
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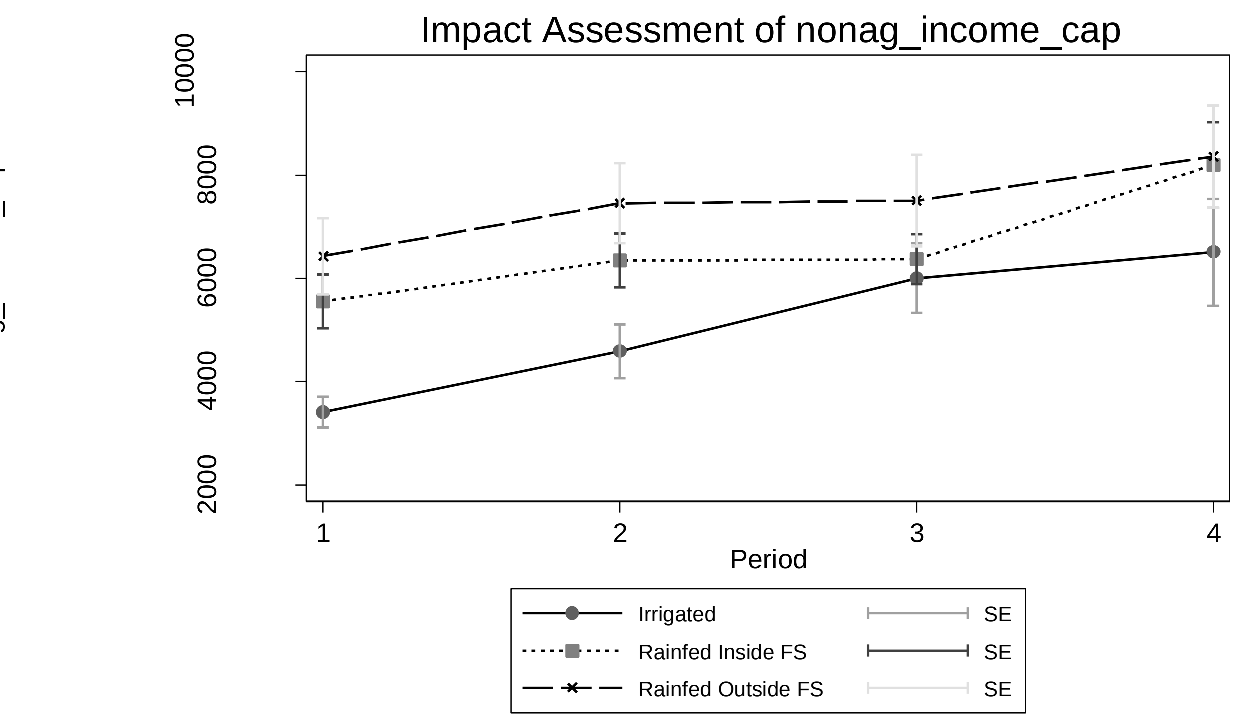
Rainfed Inside FS
SE
Rainfed Outside FS
SE


Impact Assessment of nonag_income_cap
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10000
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2
3
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Irrigated
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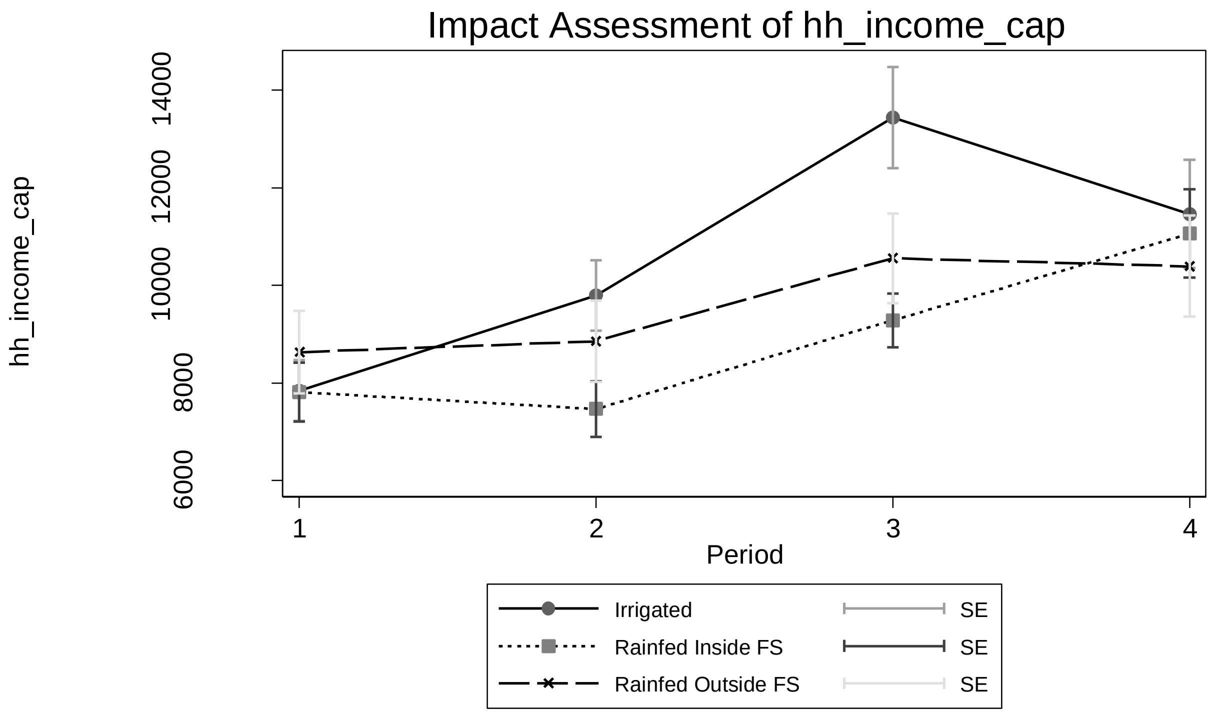
Rainfed Inside FS
SE
Rainfed Outside FS
SE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hh_income_cap
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14000
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2
3
4
Period
Irrigated
SE
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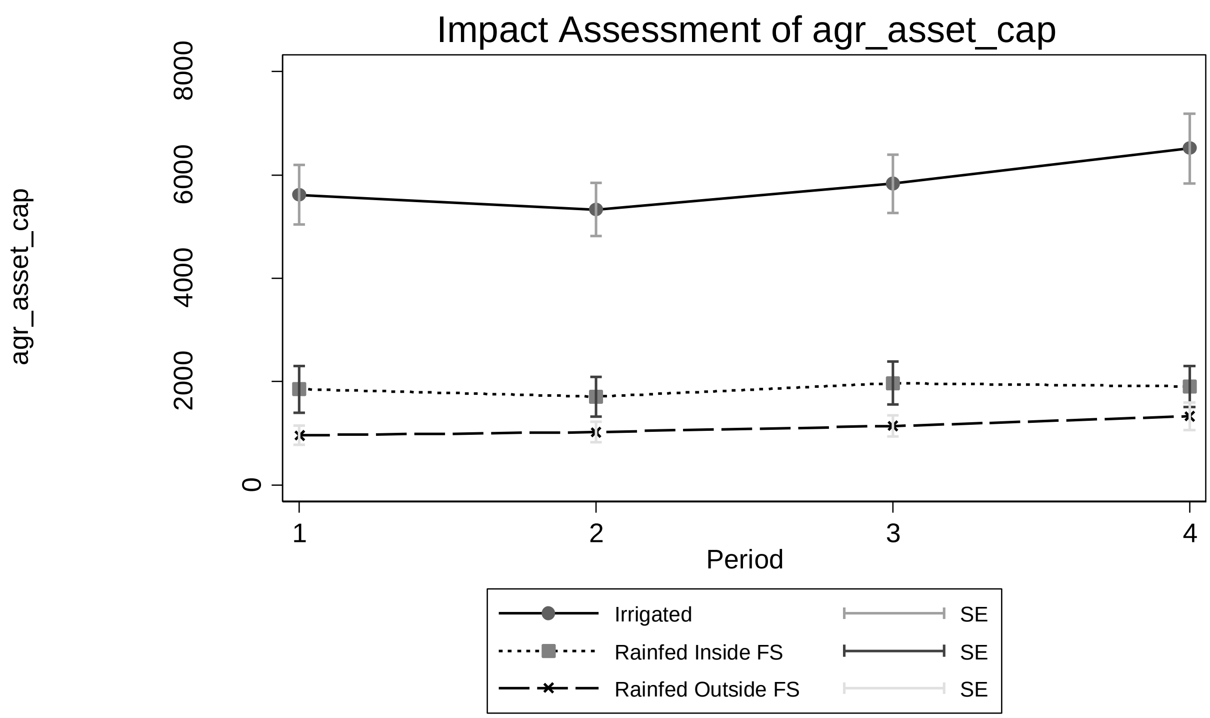
SE
Rainfed Outside FS
SE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agr_asset_cap
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4
Period
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Rainfed Outside FS
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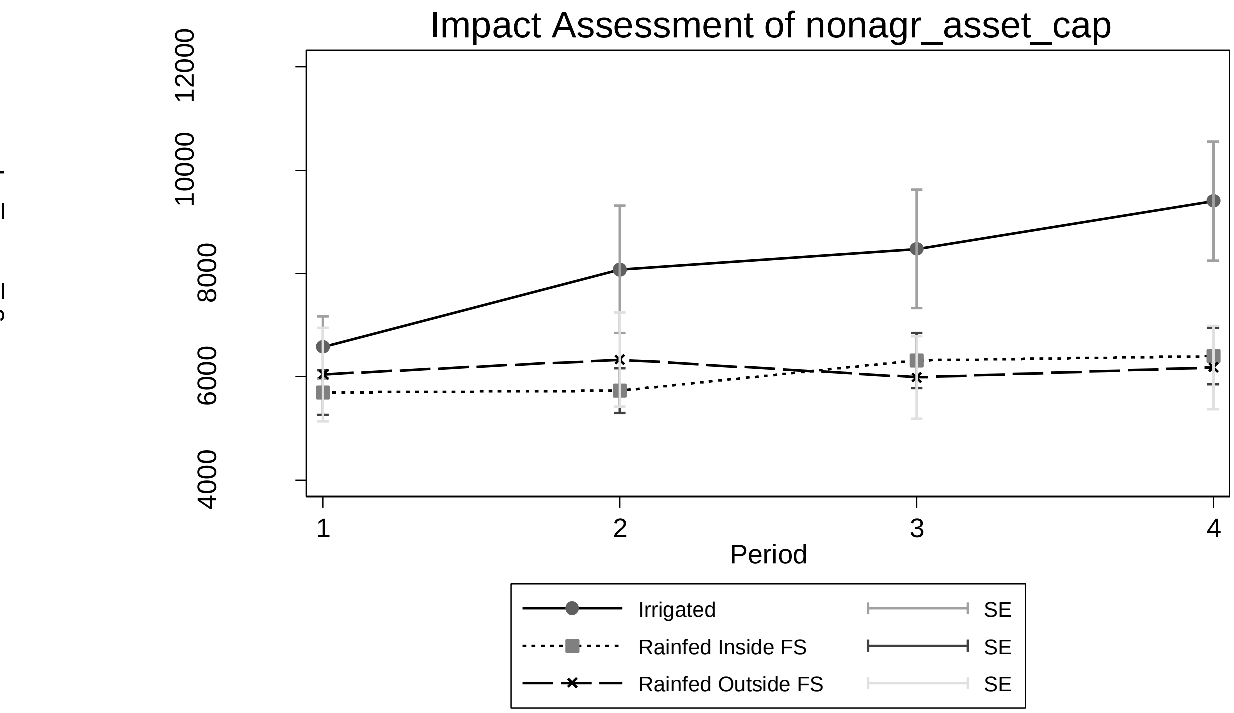
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3
4
Period
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SE
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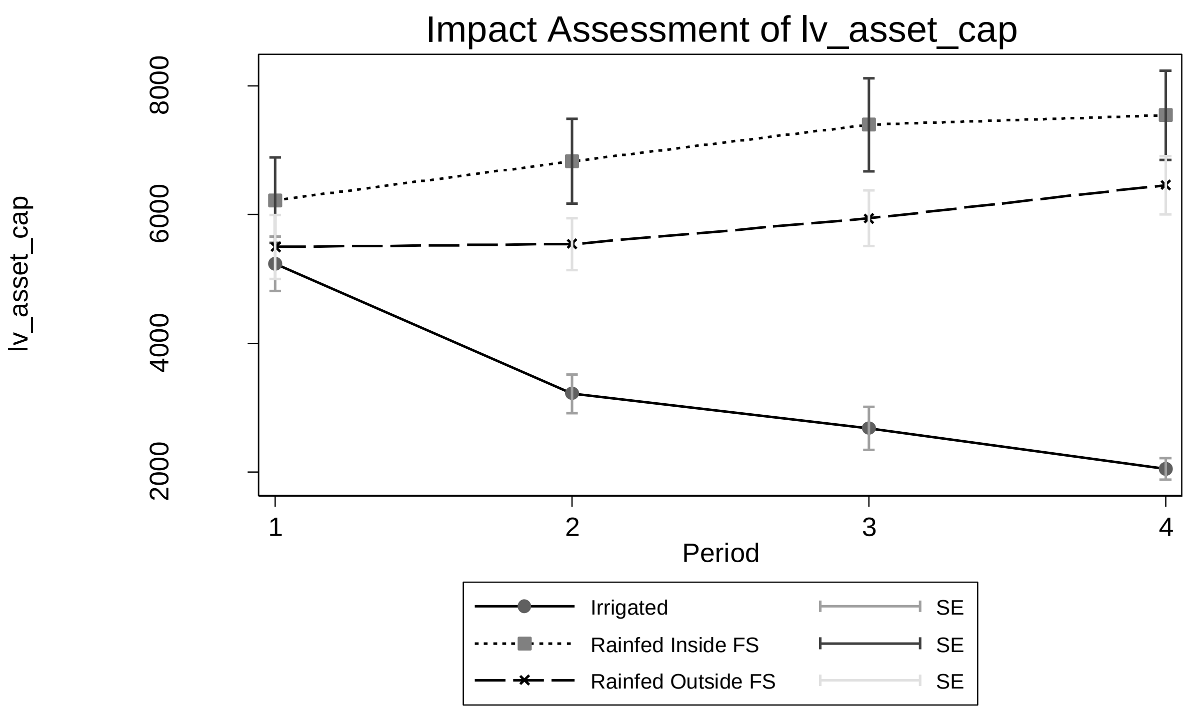
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2
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4
Period
Irrigated
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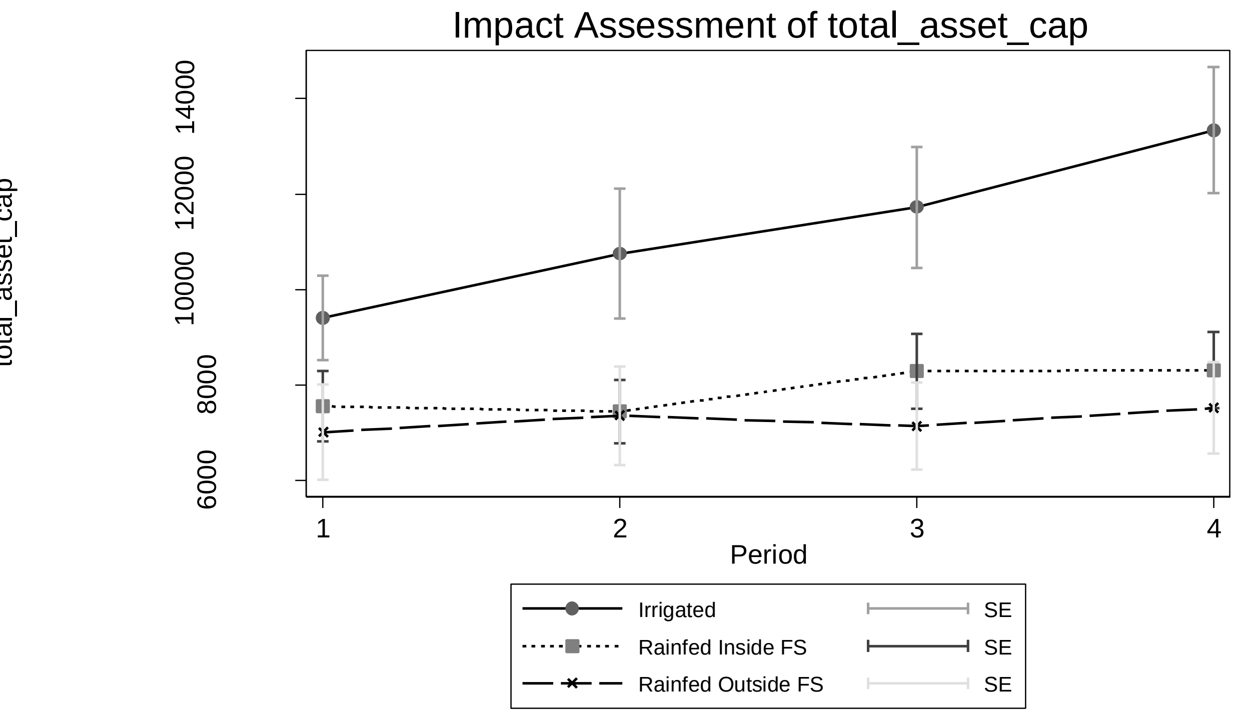
Rainfed Outside FS
SE
SE
SE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14000
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2
3
4
Period
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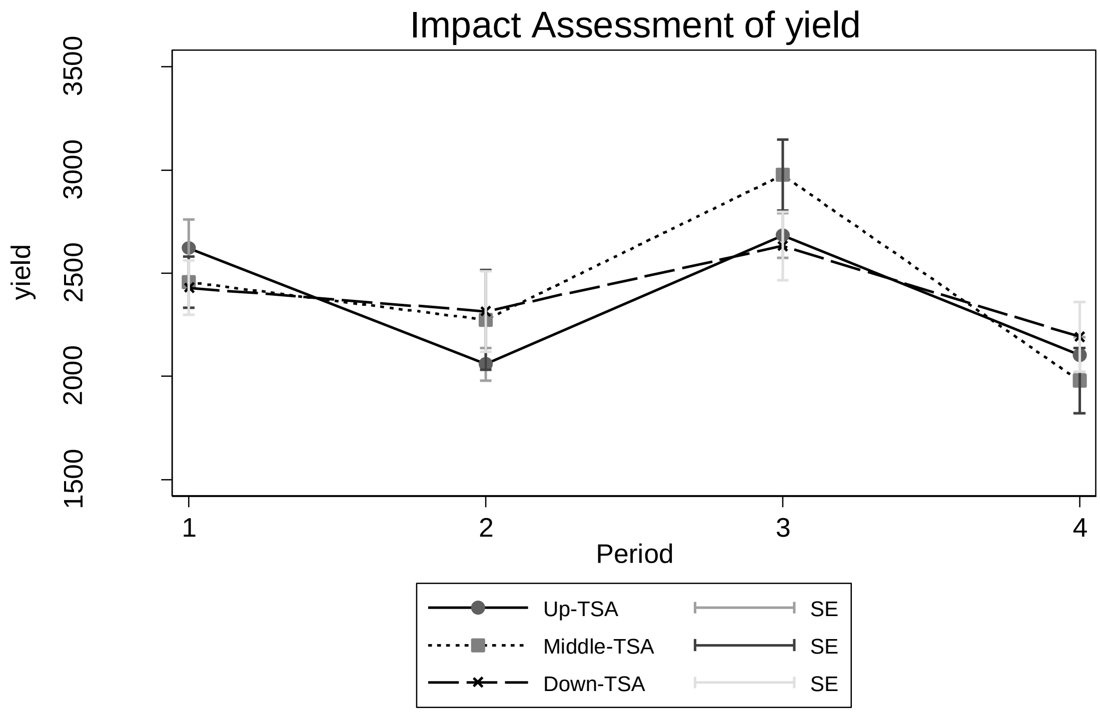
Rainfed Inside FS
SE
Rainfed Outside FS
SE

Appendix figures correspond to Figures 43 – 47.

Within TSA comparison, all TSAs (both upstream and downstream laterals)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2
3
4
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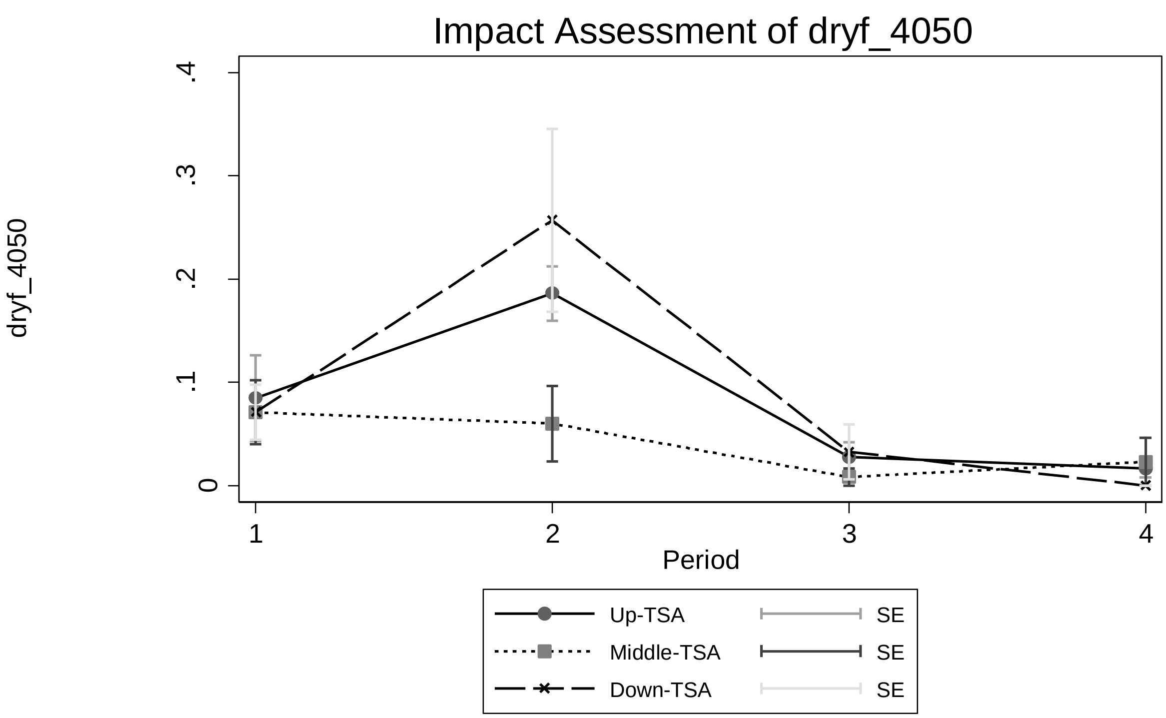
Middle-TSA
Down-TSA
SE
SE
SE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dryf_4050
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3
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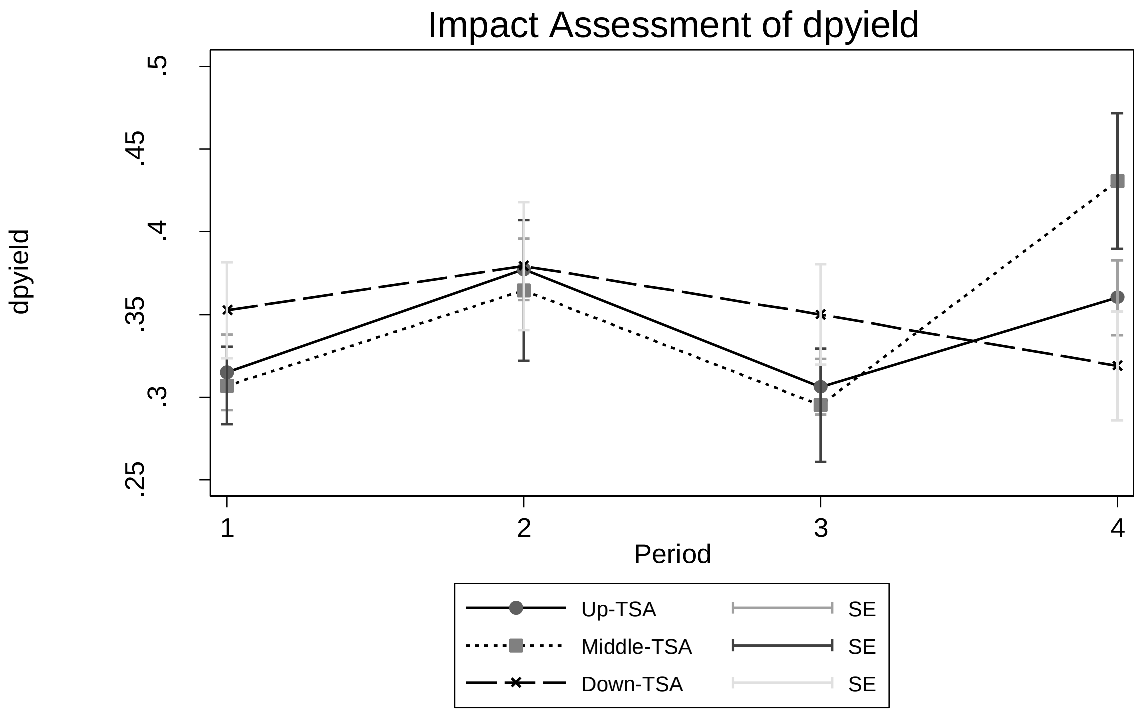
Period
Up-TSA
Middle-TSA
Down-TSA
SE
SE
SE


Impact Assessment of dpyield
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.5
1
2
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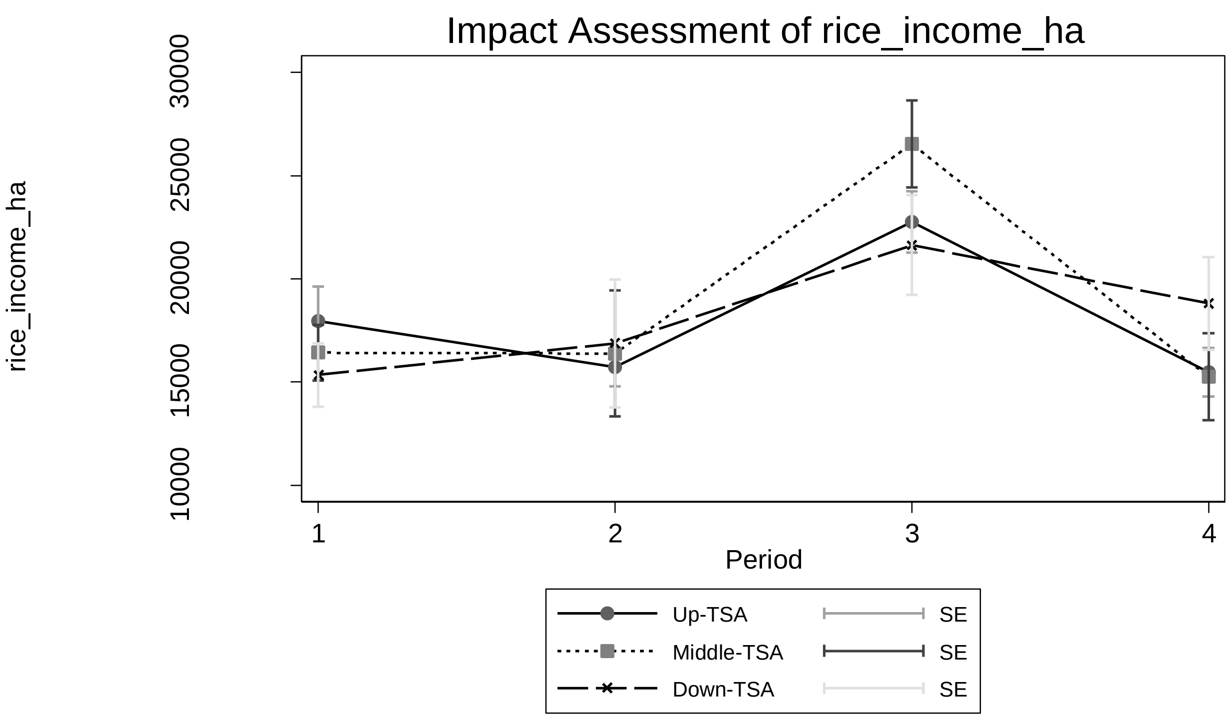
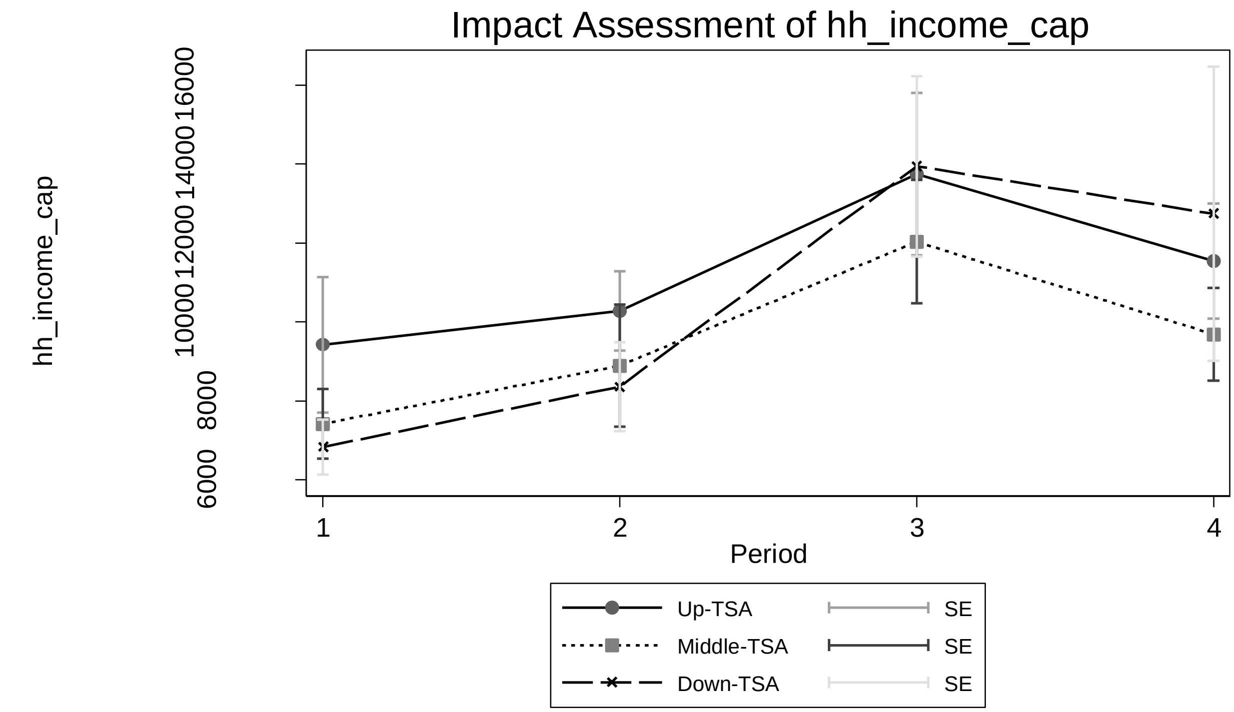
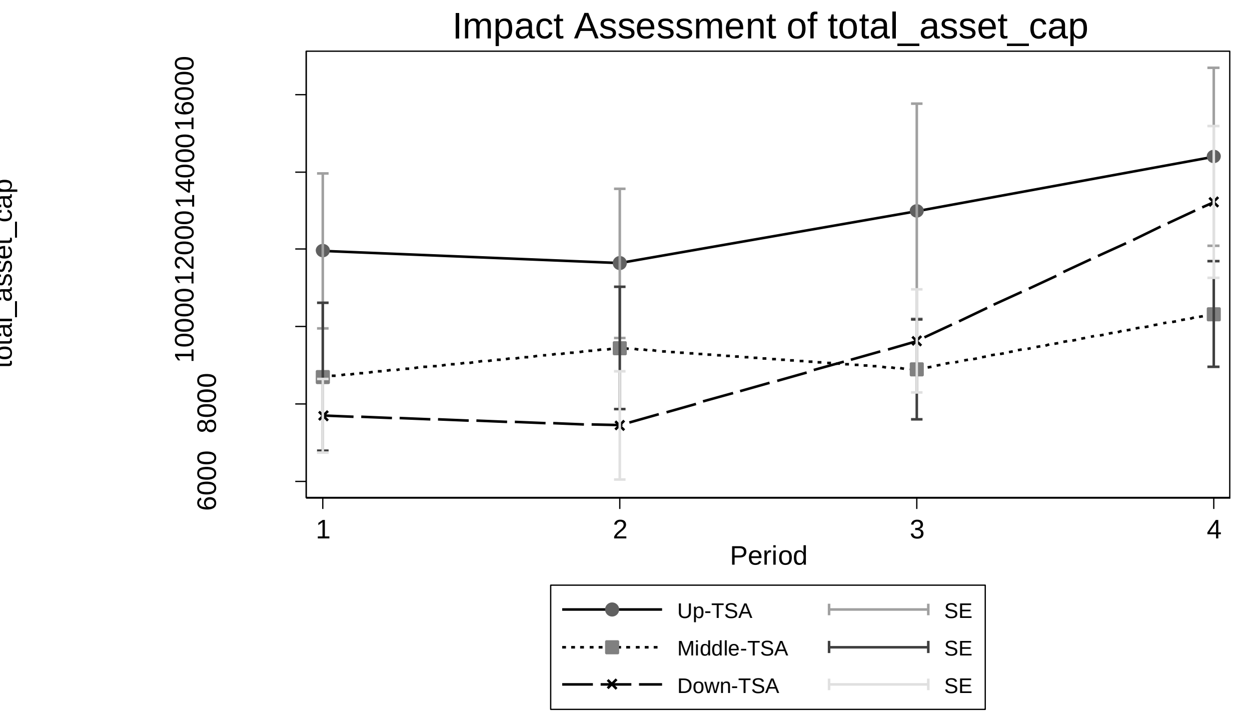
4
Period
Up-TSA
Middle-TSA
Down-TSA
SE
SE
SE


Impact Assessment of rice_income_ha
rice_income_ha
10000
15000
20000
25000
30000
1
2
3
4
Period
Up-TSA
Middle-TSA
Down-TSA
SE
SE
SE


Impact Assessment of hh_income_cap
hh_income_cap
6000
8000
10000
12000
14000
16000
1
2
3
4
Period
Up-TSA
Middle-TSA
Down-TSA
SE
SE
SE


Impact Assessment of total_asset_cap
total_asset_cap
6000
8000
10000
12000
14000
16000
1
2
3
4
Period
Up-TSA
Middle-TSA
Down-TSA
SE
SE
SE