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Benefit-cost Analysis of the Resurgent Irrigation System Program of the Philippines

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Abstract

A comprehensive assessment of irrigation investment should examine not just the benefits, but also make a systematic comparison of benefits with costs. This study has conducted this systematic comparison for investments undertaken in 2008 – 2016. Across various assessment frames, the findings converge around the following: **Costs of irrigation investment are simply too large in comparison with expected benefits**. None of the project worth indicators reach threshold levels: rather, the benefit-cost ratio (BCR) tends to fall below unity; internal rate of return (IRR) estimates tend to fall below the hurdle rate of 10 percent; and net present value (NPV) estimates tend to fall below zero.

A key limitation of our analysis is that it incorporates benefits only from incremental rice output. Rather than invalidating the government's irrigation planning and investment allocation, our benefit-cost analysis makes a case for: more skeptical treatment of irrigation area targeting; and stricter application of benefit-cost analysis, with emphasis on credible projections of both crop and non-crop benefits.

Keywords: irrigation, benefit-cost analysis, discount rate, market projection

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Benefit-cost analysis of the resurgent irrigation program of the Philippines

Roehlano M Briones*

1. Overview

That irrigation investments have benefited farmers and society at large is undeniable. Such benefits have been used to justify the massive investments in irrigation beginning 2009, following the rice price crisis. The current Philippine Development Plan (PDP) 2017-2022 targets 65.07 percent of potential area be covered by irrigated systems by end of period, up from 57.33 percent in 2015. This year, the budget for irrigation reached Php 41.7 billion on obligation basis; the National Expenditure Program (NEP) for 2019 allocates Php 36.9 billion for irrigation development on cash basis. The budget for irrigation development is expected to loom large in the national budget into the foreseeable future.

The other studies in this project highlight the myriad difficulties encountered in the design, performance, and maintenance of irrigation systems in the Philippines. These problems highlight the gap between the actual and expected benefit from these systems, with the latter determined at the planning and feasibility/project identification stage.

A comprehensive assessment of irrigation investment should examine not just the benefits of irrigation, and whether these benefits reach potential as assessed at design stage, but also to compare benefits with costs. This paper primarily aims to make this comparison to assess the net returns to society from the resurgent irrigation program. The assessment will be used as a basis for drawing policy implications for future public investments in irrigation.

The remainder of this paper is organized as follows: Section 2 lays down the methodology of the study. Section 3 provides a background by discussing irrigation sector trends, as well as past literature on benefits and costs of irrigation investment. The results of the benefit-cost analysis are reported in Section 4. Section 5 concludes.

2. Methodology

2.1 Valuation of benefits and costs

Benefit-cost analysis applies the **with-and-without** comparison: the **with** or baseline is the actual situation with irrigation investments; the **without** or counterfactual is the hypothetical situation without irrigation investments. The **increment** or change in benefit and cost is the difference in benefits and costs of irrigation investments between the two cases.

The cost of an irrigation project involves the following:

- Value of resources associated with the irrigation system itself, mainly construction cost (but also sundries such as foregone output from land occupied by canal system)

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- Value of resources associated with increased cropping intensity (CI) and increased yield.

Meanwhile, benefits from an irrigation arise from a more controlled delivery of water to a farmer's field, as an alternative to rainfall. Benefits from an irrigation project are therefore measured by the incremental value of crop output. In the Philippines, the crop that captures nearly all the benefits from irrigation is rice, i.e. irrigation programming is designed primarily to boost rice production. Incremental rice production is obtained through the following channels:

- Irrigation enables the farmer to plant during the dry season, thereby increasing CI, i.e. frequency of harvest per unit of physical land area.
- Irrigation leads to an increase in yield, through greater exposure of palay to sunlight during the dry season, and controlled timing of water delivery in the wet season.

Note that water generates multiple types of benefits, hence construction of an irrigation system generates ancillary benefits. Depending on its design, an irrigation system can be instrumental to production of potable water, electricity, and even fish; moreover, it can provide drainage service and flood management. In this paper though the valuation of benefits is limited only to that related to incremental crop production; the issue of valuing ancillary benefits is revisited in the concluding section.

Admittedly, benefit-cost analysis is best done at the level of an actual irrigation project. However, the thrust of this assessment is to assess the policy of catching up with the estimated backlog in irrigation investment over the past decade, hence will be implemented at a highly aggregated scale.

Note that at the level of individual systems, benefit-cost analysis uses the same sets of prices used to value with-project and without-project situations. Such an assumption is questionable when analysis is done at the sector-level where incremental output is large enough to affect market prices. We shall return to this issue below.

2.2 Project lifespan and measures of project worth

For an irrigation project, costs are typically incurred upfront, i.e. the first several years as the system is being established. Meanwhile benefits are realized over an extended time horizon, equal to the duration of irrigation services provided by the system; by convention, thirty years. To render the two streams comparable, the suitable method is discounting to present value, using a social rate of discount. The difference between total discounted benefits and total discounted costs is called *NPV* (net present value) Letting *t* denote time periods; B_t, C_t the benefits and costs, respectively, for each period; and *N* the total number of periods in the lifespan of the irrigation project(s); and *r* the social discount rate; then *NPV* is calculated as follows:

$$NPV = \sum_{t=0}^{N} \frac{B_t - C_t}{\left(1+r\right)^t}$$

The official social discount rate for evaluating projects is 10 percent following the latest National Economic Development Authority (NEDA) guidelines (NEDA, 2016). Meanwhile the ratio of total discounted benefits to total discounted costs is the benefit-cost ratio (BCR).

Lastly, the discount rate needed to equate NPV = 0 is the internal rate of return (IRR). The project merits social investment when NPV > 0; BCR > 1; or IRR hurdles the social discount rate.

2.3 Time horizon

The time interval over which irrigation investment was implemented is 2008-2016. Assessment done only over the past horizon is called **ex-post** assessment. The advantage of evaluating over a past period is that actual prices and quantities are known. If the evaluation interval ends in 2016, then incremental benefits can be estimated from differences in yield and CI between irrigated systems (with-investment) and rainfed systems (without-investment). However, the estimate of cost cannot be the entire development cost, as that cost was incurred to generate a stream of benefit over into the future. Rather, the past benefits must be made comparable to some measure of past costs. This can be most readily implemented by converting the total irrigation investments into a stream of annuity values over the relevant past interval. Letting PV denote present value of the asset, then annuity payments P over N periods are given by the following formula:

$$P = \frac{PV \cdot r}{1-\left(1+r\right)^{-N}}$$

Alternatively, the interval can extend up to the future period in which the benefit stream from irrigation accrues. In this case the entire development cost of the investment can be used, dispensing with annuity value. However, there is obviously no data about future prices by which to value the incremental output. To generate estimates of future prices, we apply a multi-market equilibrium model, the Agricultural Market Model for Policy Evaluation (AMPLE). A complete description of AMPLE is found in Briones (2013).

2.4 Using AMPLE to generate Baseline and counterfactual scenarios

Note that each year in AMPLE is a three-year average to smooth out vagaries of agricultural production (a standard practice in multi-market agricultural policy models). That is, AMPLE year 2015 is as a three-year average for 2014-16. Hence 2016 (interpreted as the average for 2015-2017) is a suitable starting point for the projection.

AMPLE will be used to generate a baseline scenario which incorporates the with-irrigation case. The baseline will incorporate a key policy reform to be implemented in 2019, namely the repeal of the quantitative restriction (QR) on importing rice. The QR has hitherto been implemented under the import monopoly of the National Food Authority (NFA) conferred by Presidential Decree No. 4. The QR prevents the domestic price of rice (wholesale level) from converging with the world price in terms of milled rice; consequently, palay price is also elevated compared to the no-QR scenario. As of late 2018, Congress has already passed a law, entitled "An Act Liberalizing the Importation, Exportation and Trading of Rice, Lifting for the Purpose the Quantitative Import Restriction on Rice, and for Other Purposes". The Act converts QRs into tariffs, equivalent to bound rates of 35 percent for ASEAN country imports; 40 percent for MFN imports in-quota; and 180 percent for imports out-quota (the "quota" or minimum market access set at 350,000 tons). The law is expected to be signed, and implementing rules and regulations drafted, within early 2019.

Implementing the counterfactual scenario involves shocking an area share parameter in AMPLE which leads to endogenous area harvested for each crop, including irrigated rice. Relevant equations of the AMPLE model are given in (1) to (7) below. Let *i* index the crops of AMPLE, and *j* the non-land inputs. Crop output QSS_i is obtained by multiplying area harvested A_i by the yield per ha Y_i (Equation 1). Yield itself is obtained from a Cobb-Douglas production function; at the profit optimum, per ha supply is a function of producer prices PP_i, input prices w_j, and various parameters (Equation 2). The net revenue function $NREV_i$ is given by total revenue, net of the factor share of non-land inputs equal to αY_i (Equation 3).

$$QSS_i = A_i * Y_i \quad (1)$$

$$Y_i = \left[\left(PP_i^{\alpha Y_i} \right) * \left(\alpha 0 Y_i \right) * \prod_j \left(\alpha 1 Y_{ij} / w_j \right)^{\alpha 1 Y_j} \right]^{\frac{1}{1-\alpha Y_i}} \quad (2)$$

$$NREV_i = \left(1 - \alpha Y_i \right) * PP_i * Y_i \quad (3)$$

$$A = \left(\sum_i \beta_i A_i^{\rho} \right)^{\frac{1}{\rho}} \quad (4)$$

$$atot = \sum_i A_i \quad (5)$$

$$LAM * ATRAN * atot = \sum_i NREV_i A_i \quad (6)$$

$$A_i = ATRAN * atot * \left(LAM * \beta_i / NREV_i \right)^{\sigma A} \quad (7)$$

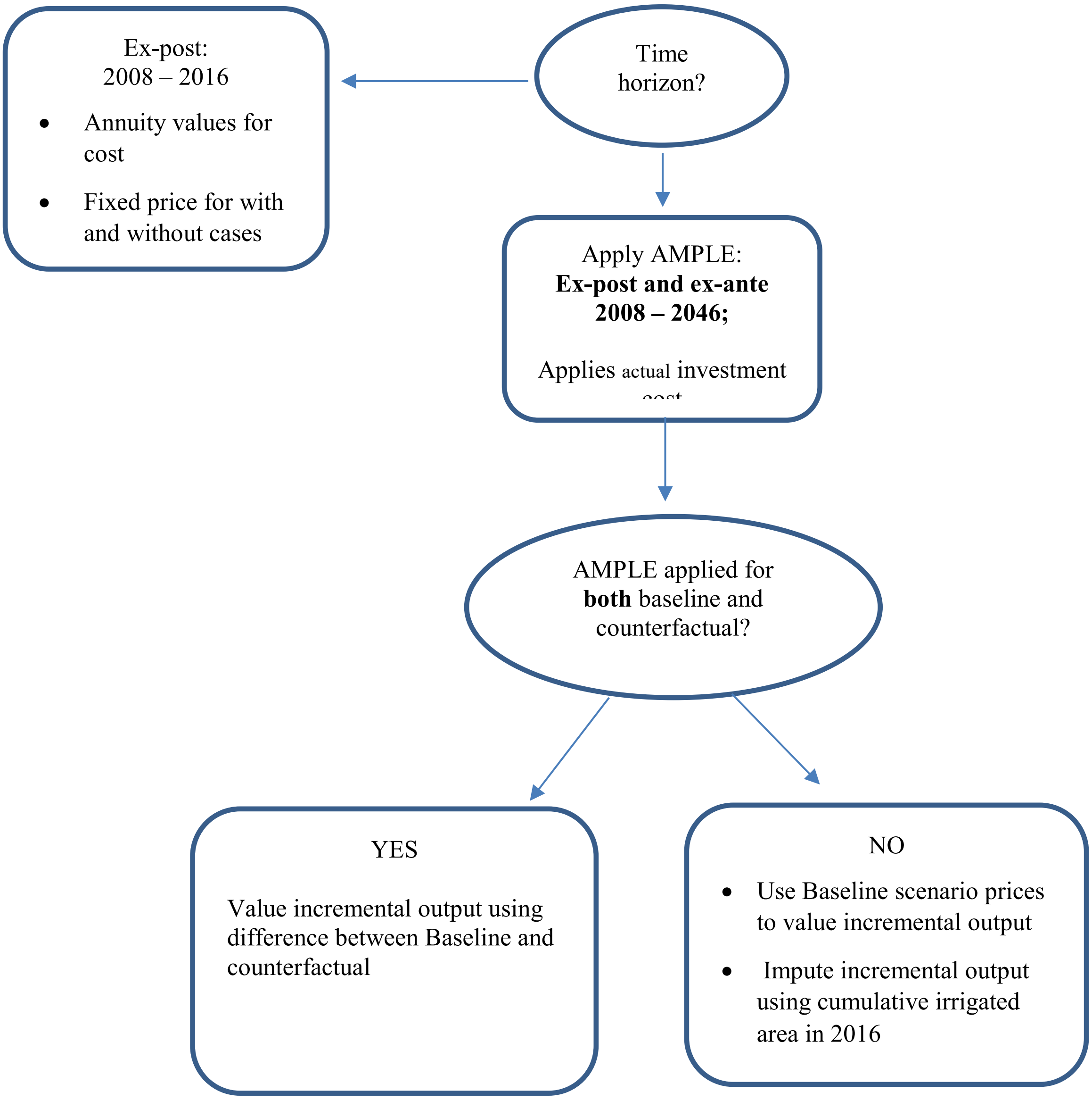
The interesting part of the framework is Equation (4), which expresses total area harvested as a constant elasticity of substitution function of the area harvested of each of the crops, together with a share parameter β_i . Further imposing the constraint that total area *atot* is the sum of area harvested by crop (Equation 5) gives rise to an adjustment variable *ATRAN;* in conjunction with minimizing cost by choice of area harvested, subject to an overall area harvested constraint, then total net revenue across all crops is product of the Lagrange multiplier *LAM*, the adjustment variable *ATRAN*, and *atot.* The same factors, together with the share parameter in Equation (4), and $NREV_i$, determine area allocation under minimum cost (Equation 7). It is this share parameter that can be shocked in order to calibrate the difference in irrigated area due to investment.

2.5 Summary of assessment frames

To synthesize the foregoing discussion: benefit-cost analysis will be conducted under several of assessment frames, summarized in a flow chart (Figure 1). The first decision point for the benefit-cost analysis is the time horizon of the assessment. If the horizon is limited to the past, then the assessment frame is **Ex-post assessment**. Incremental benefits are compared to annuity value of development costs over the period 2008 – 2016. On the other hand, if the horizon includes the future, then the assessment frame is **Ex-post and ex-ante**. The ex-ante projection applies the AMPLE. The baseline incorporates projections of future price and output, together with policy reform in 2019 as rice import quotas are converted to tariffs, set at 35 percent.

The next decision point is generating the counterfactual scenario. One option is to apply AMPLE itself, representing the counterfactual by an appropriate shock affecting the size of irrigated area in 2016. Net present value and other measures of project worth are obtained by comparing the baseline with the counterfactual scenario. Alternatively, AMPLE is only used to generate projections for baseline scenario for prices; incremental output is obtained from the cumulative irrigated area, multiplied by difference in CI and average yield between irrigated and rainfed systems.

Figure 1: Assessment frames for benefit-cost analysis

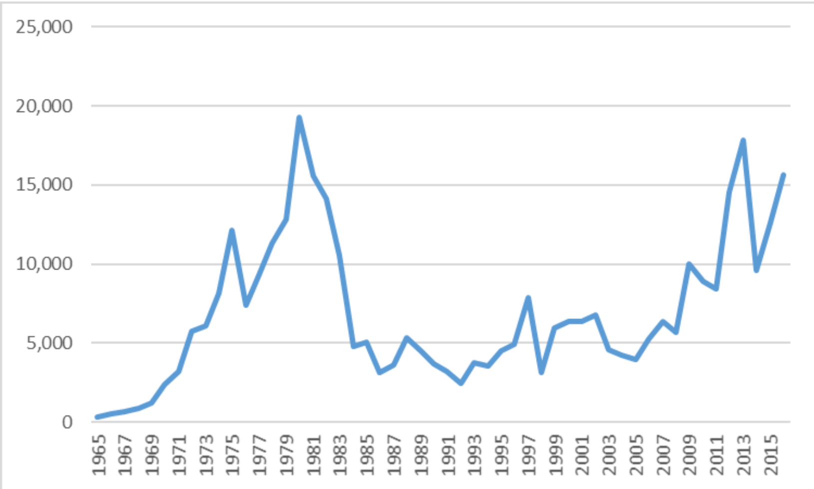


3. Background

3.1 Irrigation expenditures

Spending on irrigation reached a peak in the late 1970s when expenditures approached Php 20 billion in 1979 in 2000 prices. With the economic crisis of the early 1980s, expenditures plummeted to below Php 5 billion by 1984. Since that time until 2008, irrigation expenditures stayed within the Php 5 to Php 8 billion range. However, the rice price crisis in that year, when world price of rice breached USD 1,000 per ton, reinvigorated the policy of rice self-sufficiency. In 2009 expenditure breached the Php 10 billion mark; it continued to trend steeply upward in the subsequent years, until it again approached the Php 20 billion high water mark in 2013.

Figure 2: Expenditures on irrigation, in 2000 prices, 1965 – 2016 (Php millions)



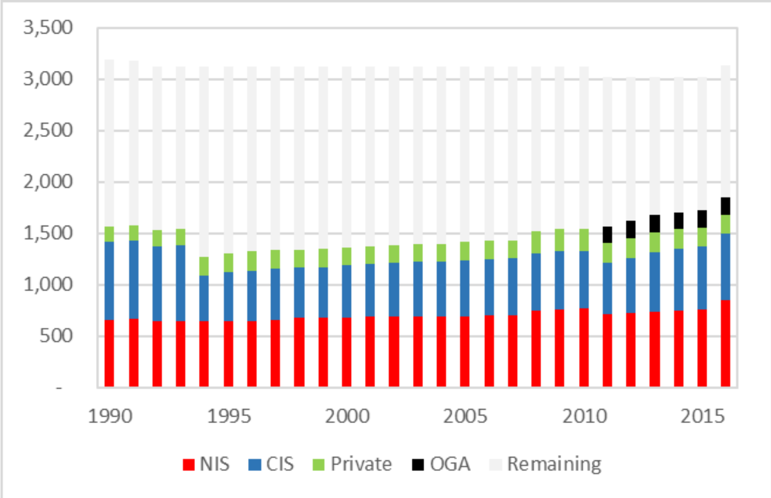
Source: Inocencio (2018).

3.2 Production and area trends

The area of irrigated systems has been growing; recently expansion has accelerated, particularly for communal systems.

Total irrigated area of the country in 2016 was about 1.86 million ha (Figure 3), of which about 46 percent are national irrigation systems (NIS), and 35 percent are communal irrigation systems (CIS). The remainder (19 percent) are composed of other government systems, plus private irrigation systems. NIS corresponds to government irrigation systems from 1,000 and higher, administered by the National Irrigation Administration (NIA). CIS consists of systems below 1,000 which are administered by local government units (LGU) and fully managed by irrigators' associations (IAs).

Figure 3: Irrigated area, by system, 1990 – 2016, '000 ha



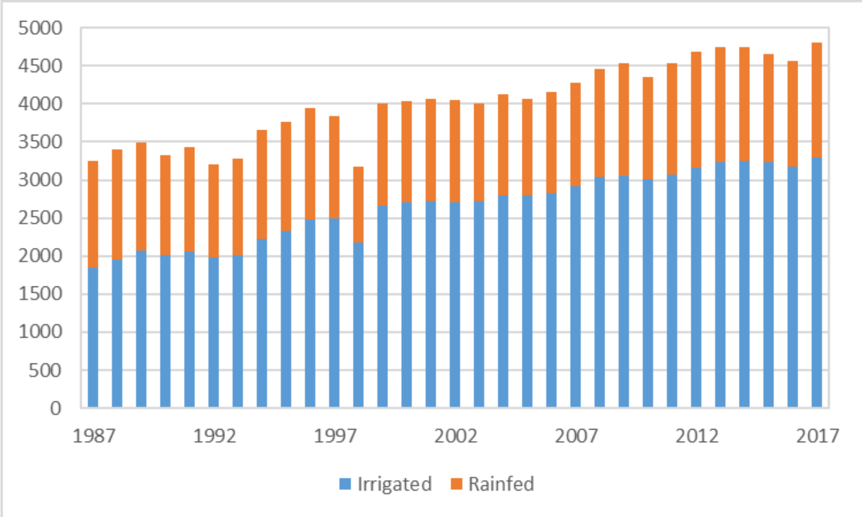
Source: PSA Countrystat.

Estimated CIS area underwent a huge revision in 1994 after a validation exercise by NIA. Meanwhile in 2011-12 some NIS and CIS areas were converted to other government systems (hence the dip in area for both). Nonetheless comparing with baseline figures in 1994, the country's irrigated area in 2016 was 46 percent larger. In particular, growth rate of irrigated area was fastest in 2011- 2016 at an annualized rate of 3.4 percent, compared to an annualized rate of 1.15 percent in 1996-2011, consistent with the rise in irrigation investment discussed previously. In the recent period, growth rate of CIS was even faster, reaching an annualized rate of 5.5 percent.

Over the long term, area harvested for all palay and irrigated palay have been increasing, but the pace of growth has slowed since 2011.

As expected, the expansion in irrigated area has led to an increase in area harvested both for all palay and irrigated palay (Figure 4). However, the acceleration in the growth of area from 2011 onward has been accompanied by deceleration in growth of area harvested of irrigated palay and total palay. The reason for this is a contraction in irrigated area in 2015-16 and a contraction in rainfed area in 2014-16. The former in turn is attributed to a severe El Nino in 2015-16; area harvested has however only weakly recovered after the event.

Figure 4: Area harvested, by system, 1987-2017, '000 ha

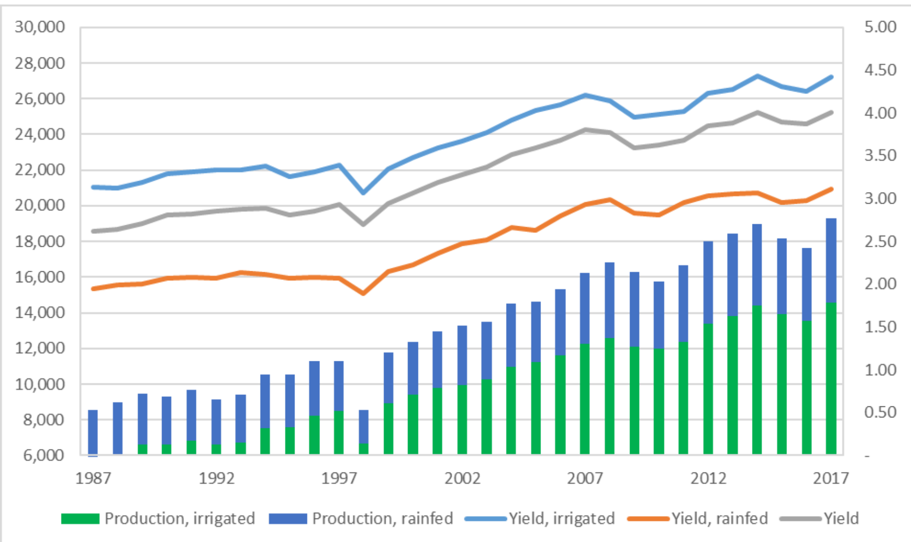


Source: Countrystat.

Compared to rainfed palay, irrigated palay is produced with higher yield and at lower cost; however, yield and cropping intensity of irrigated palay has recently been falling.

Palay production has been increasing from just 8.5 million tons in 1987 up to an all-time high of 19.3 million tons in 2017 (Figure 5). However, output has seen intermittent dips, most recently in 2015-2016 owing to an El Nino episode. Previously, similar bouts of El Nino caused output to fall in 2009-2010 as well as 1997-1998. Yield of palay has likewise been an upward trend, though an erratic one, reaching a peak of 4.0 tons per ha in 2014, after which it declined. In 2017 though it recovered to the same level of 4.0 tons per ha. While both irrigated and rainfed palay follow trend up, irrigated palay retains a consistent yield advantage over rainfed palay (40 to 50 percent).

Figure 5: Production ('000 tons) and yield (tons per ha), by system, 1987-2017

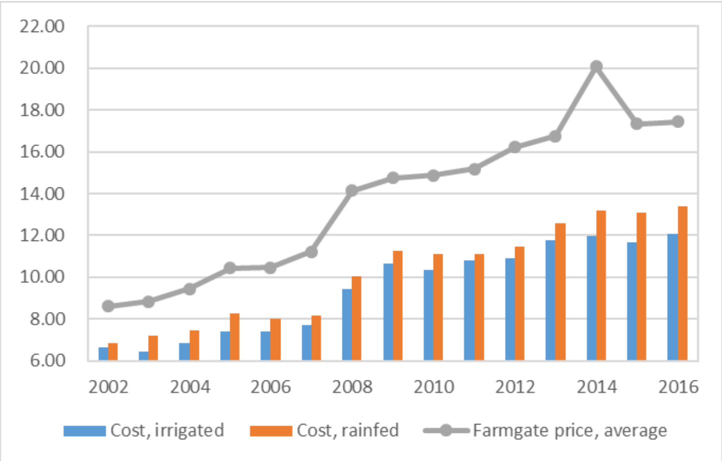


Source: Countrystat.

Irrigated palay has a significant cost advantage over rainfed palay, and at farmgate realizes a sizable margin over production cost.

Production cost per ha for irrigated palay exceeded Php 50,000 per ha since 2013, compared to Php 40,000 per ha for rainfed palay. However, owing to higher yield, irrigated palay has a significant cost advantage (Figure 6). Production cost of irrigated palay ranges from 11 to 12 pesos per kg since, 2011, compared to rainfed palay, which ranges from 11 to 13 pesos. The average cost advantage is about 8 percent. Production of irrigated palay realizes a sizable margin of farmgate price over production cost, averaging 50 percent since 2011; as rainfed palay is priced nearly the same, the margin over production cost for rainfed palay is somewhat lower.

Figure 6: Cost and returns, by system, 2002 – 2007, in pesos per kg

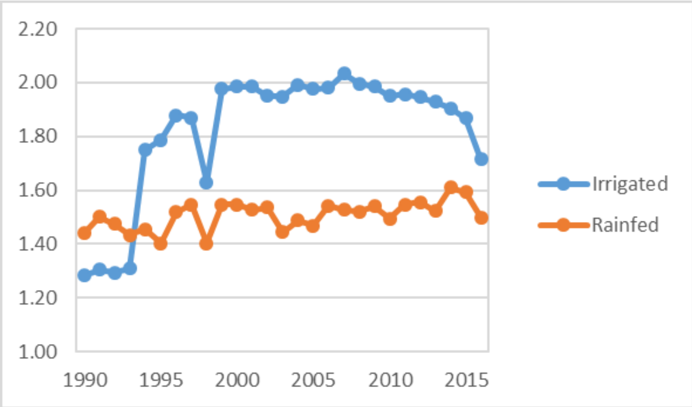


Source: Countrystat.

Cropping intensity of rainfed systems exceeds unity and has been relatively stable, whereas that of irrigated systems rose to more than 2 and then declined.

CI for irrigated systems is simply the ratio of area harvested for irrigated palay, to total irrigated system area. CI for rainfed systems is the ratio of total area harvested per year for rainfed palay, to area harvested in the second semester (the rainy season). The ideal is CI of 2 or more for irrigated systems, while the expectation is CI = 1 for rainfed systems. In fact, CI for irrigated systems approximated 2 only in 2000 to around 2007 (Figure 7). During the period of resurgent irrigation investment, CI began to decline, reaching a low point in 2016. This is consistent with expansion in irrigation investment discussed above, together with area under irrigation, but the weak growth in area harvested since 2010.

Figure 7: Cropping intensity estimates, by system



Source of basic data: Countrystat.

3.3 Past studies on benefits and costs of irrigation

Early evaluations of irrigation systems noted large discrepancy between expected and actual performance.

The first wave of irrigation investments in the 1970s and early 1980s was followed by several evaluations in the 1990s. David (1990) observed that gains in cropping intensity and yield were low, owing to poor performance of the country's irrigation systems. For the nation's flagship irrigation projects, namely the Upper Pampanga River Integrated Irrigation System (UPRIIS), he noted the following technical problems:

- Assumptions on water availability, efficiency, water requirement, and sediment inflow, were systematically over/understated to raise the economic internal rate of return (EIRR). For example, at feasibility study stage the UPRIIS was appraised at EIRR of 13.0 percent, but ex post was reappraised at 8.9 percent (which falls below the 12 percent cut-off).
- Design philosophy tends to be highly unrealistic. For instance, UPRIIS design engineers introduced double-gated water control structures that are too sophisticated for farmers and watermasters to operate. There is no interaction between design engineers and farmers about proper design and operations.
- Irrigation-related agencies fail to coordinate. Design engineers do not communicate with O&M engineers for feedback and advice. Agencies in charge of watershed management are unable to control sedimentation rates (reaching up to 375 percent above appraisal estimate). The Pantabangan Watershed Management and Erosion Control was poorly conceived and unable to control the flow of sediment into the Pantabangan Dam.

Similar findings were broached in World Bank (1992). Design improvements are warranted, namely:

- Greater attention should be devoted to siltation, erosion, and related problems.
- A more realistic approach to water control is required, towards staggered and rotational rather than continuous supply.

There is also potential for improving operations and maintenance, in the following areas:

- Minimizing silt inflows.
- Optimizing reservoir rules
- More effective utilization of rainfall and return flows
- Systematize rotational distribution and/or staggered transplanting

The following principles are propounded as guidelines for future investment:

- Large multi-purpose projects are likely to prove justified only if the costs of headworks and other joint facilities can be attributed primarily to purposes such as electric generation.
- New run-of-the-river national projects will continue to be important but many are high cost with a limited dry season water supply and/or difficult physical conditions;
- Communal irrigation remains a relatively high priority, subject to rigorous application of agreed selection criteria to ensure that high cost and econo.micallyl ow return projects are avoided.

The report notes with concern the policy thrust of rice self-sufficiency which is driving large investments in irrigation. The important role of rice self-sufficiency is reiterated in a study of investments in irrigation from 1953 to 1988. Kikuchi, Maruyama, and Hayami (2001) showed that public investments in irrigation was explained by an indicator of rice self-sufficiency, as well as short-run changes in world rice prices (which affect rates of return to investments).

A review of the literature up to the mid-1990s (David, 1995) confirms these findings, with some additional observations:

- On average actual irrigated area is only 75 percent of design service area; large systems have a smaller ratio than small systems; and new irrigation projects (after 1972) tend to have much lower ratios (56 percent) compared to older systems (94 percent for projects before 1965).
- Selected foreign-assisted projects exhibit overruns in terms of time (60 percent on average) and cost (50 percnt on average), with EIRR at completion dates generally lower than at appraisal dates, across a wide range of irrigation systems.
- Overestimates of EIRR are due not only to overestimates of service area, but also to failure to anticipate declining world prices of rice, which are the basis for imputing the shadow price of domestic rice.

4. Findings

4.1 *Ex-post 2008 – 2016*

Table 1 presents summary of investment costs for the past horizon for 2008 – 2015; meanwhile the impact of irrigation is shown in Table 2. For Table 1, the investments summarized in the "Totals" rows involve projects with the following classification, with intervals for completion of construction:

- Totally new construction: 3 years
- More than 50 percent new construction: 2 years
- Less than 50 percent new construction: 1 year
- Total rehabilitation: 1 year
- Other: 1 year

Table 1: Investment costs of irrigation projects, Philippines, 2008 – 2016, Php millions

	Total	2008	2009	2010	2011	2012	2013	2014	2015
Total, market prices		8,327	15,201	14,107	13,858	24,326	30,530	16,969	22,115
Total, 2006 prices		1,423	13,093	11,707	10,990	18,698	22,784	12,164	15,629
Annuity value		7,632	7,632	7,632	7,632	7,632	7,632	7,632	7,632
NPV, annuity value	44,788	7,632	6,938	6,307	5,734	5,213	4,739	4,308	3,916

Source: Author's calculations.

The horizon is truncated at 2015 as the projects with the shortest duration to realizing benefit is one year. Based on market prices, irrigation investments in nominal terms rose from Php 8.4 billion in 2008 to Php 22.1 billion in 2015. Deflated to 2006 prices, the corresponding amounts are Php 1.4 to Php 15.6 billion. The estimated annuity value is Php 7.63 billion every year, for which the discounted value in turn is Php 44.8 billion.

As for impact, benefits from investment are felt from 2009 onward as irrigation investment takes at least one year to generate incremental output. The change in irrigated area is computed from a base year 2008, i.e. it is the **cumulative** change in irrigated area from 2008 onward. The value of incremental output is computed from the change in irrigated area, multiplied by the palay price, difference in yield, and difference in CI. The latter is computed not based on actual difference in CI of irrigated areas and non-irrigated areas, but rather as CI of irrigated areas less unity; this tends to bias the calculation of incremental output upwards The resulting incremental output begins from just Php 326 million in 2009, rising to Php 5.8 billion by 2016.

An additional source of benefit is the reduction in incremental cost, computed as the difference in cost per ton, multiplied by the change in irrigated area, and the total yield in irrigated areas. The resulting incremental cost is Php 46 million in 2009, rising to about Php 2 billion in 2016. The total benefit in real terms is the sum of incremental output and cost savings.

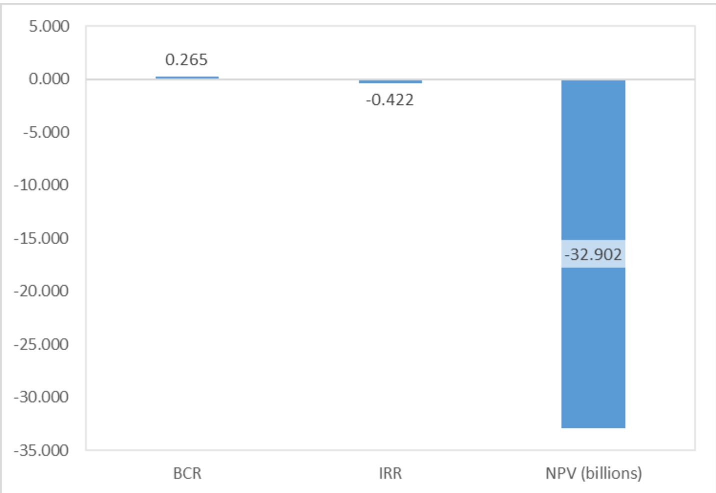
Table 2: Estimated impact of irrigation, Philippines, 2008 – 2016, Php millions

	Total	2009	2010	2011	2012	2013	2014	2015	2016
Change in irrigated area (ha)		19,995	22,726	74,499	122,253	181,900	211,089	235,730	362,301
Palay price (Php per ton)		14,760	14,870	15,170	16,220	16,760	20,070	17,330	17,430
Difference in yield		1.1	1.2	1.1	1.2	1.2	1.4	1.4	1.3
Difference in CI		1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.7
Incremental returns		326	378	1,154	2,246	3,433	5,210	4,789	5,787
Difference in cost (Php per ton)		-580	-730	-330	-540	-840	-1,210	-1,390	-1,270
Incremental cost		-46	-66	-99	-280	-653	-1,131	-1,413	-1,958
Total benefit, 2006 prices		320	369	993	1,941	3,049	4,545	4,383	5,379
Discounted value of benefit	11,885	291	305	746	1,326	1,893	2,566	2,249	2,509

Source: Author's calculations using PSA data.

The measures of project worth based on Tables 1 and 2 are shown in Figure 7. The net present value (discounted benefits less discounted costs) is –Php 32.9 billion, as costs greatly exceed benefits; this is reflected in the BCR, which shows discounted benefits are only 26.5 percent as large as discounted costs. No amount of positive discount rate can alter this outcome; in fact, the discount rate has to fall to -42.2 percent in order to achieve a zero NPV.

Figure 8: Measures of project worth, irrigation investments, ex-ante 2008 - 2016



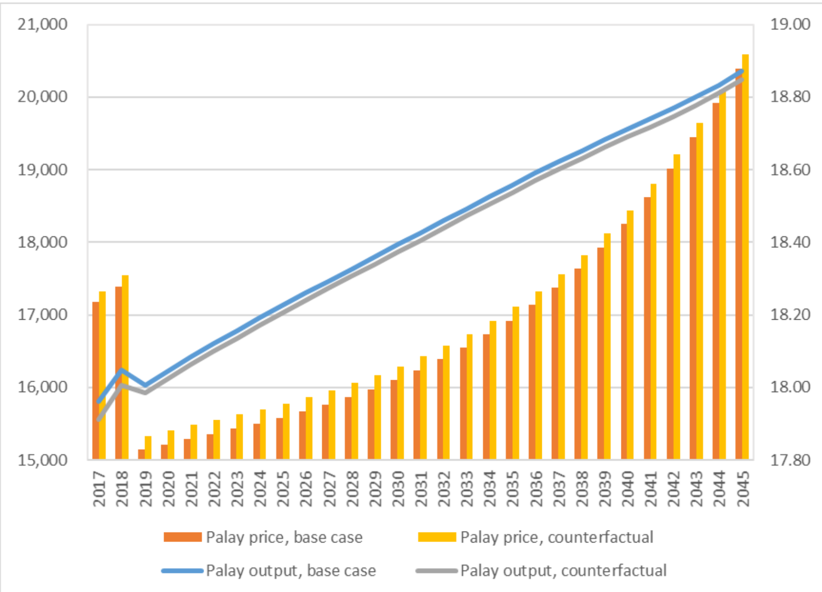
Source: Author's calculations.

4.2 *Ex-post and ex-ante, 2008 – 2045*

Next we examine the assessment frame involving the combination of ex-ante and ex-post horizon. The baseline scenario incorporates projected population and income growth to 2045 to account for changes in demand to 2045. For the counterfactual scenario, we set a change in share parameter by 4.2 percent. From the ex-post analysis, we compute the cumulative area harvested by 2016, adjusted by difference in cropping intensity (rainfed vs. irrigated), as 258,673 ha. The aforementioned shock to β_i leads to a decline area harvested for irrigated rice equal to 259, 905 ha, a close approximation. The results of the Baseline and counterfactual scenarios are shown in Figure 8.

In the baseline scenario, output rises from 15.8 to 20.4 million tons, whereas in the counterfactual, output rises from 15.5 to 20.2 million tons (Table 3). In both cases, rounding off reduces annual growth to just 0.9 percent. Trends in palay price are also very similar; under the base case, palay price goes from Php 18.24 per kg in 2017, up to Php 18.88 (in 2015 prices) in 2045. Compare this to an actual 2017 price (for "Other paddy varieties") equal to Php 18.21 per kg. Meanwhile, in the counterfactual scenario, 2017 palay price is a very similar Php 18.26 per kg, rising to Php 18.92 in 2045.

Figure 9: Palay output and palay price, base and counterfactual case, 2017-2045



Source: Author's calculations.

Note that palay prices experience a relatively big drop in 2019 whether in the baseline or the counterfactual scenario. This is attributed to the policy reform of tariffication envisaged to be adopted in 2019. The implicit tariff rate for milled rice (84.3 percent in 2014-2016) falls by assumption to a 35 percent explicit tariff rate from 2019 onward.

The figures shown in Table 4 imply incremental returns starting at Php 4.3 billion in 2017; however, the incremental returns decline to just over Php 1 billion pesos per year over the subsequent decades, as the difference between with and without case narrows over time. Together with the incremental cost savings, total benefit deflated to 2006 prices reaches Php 3.1 billion in 2017, down to just Php 1 billion or below in subsequent years. With discounting, benefits accruing in later years declines to single digit levels.

Table 3: Palay output and price, projections for 2017 to 2045

	2017	2027	2037	2045
Palay output, base case	15,813	17,465	19,107	20,357
Palay price, base case	18.24	17.95	18.27	18.88
Palay output, counterfactual	15,551	17,364	19,001	20,244
Palay price, counterfactual	18.26	17.99	18.31	18.92

Source: Author's calculations.

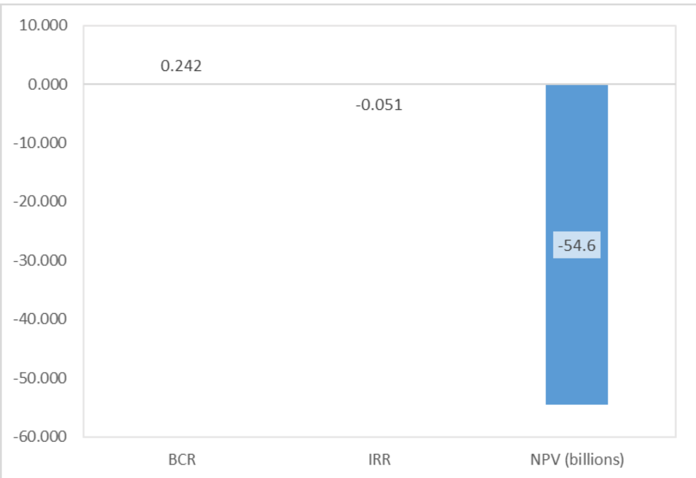
Table 4: Palay output and price, projections for 2017 to 2045, in Php millions

	2017	2027	2037	2045
Incremental returns	4,320.22	1,127.70	1,210.78	1,351.72
Difference in cost (Php per ton)	-861	-861	-861	-861
Incremental cost	-225.49	-86.42	-90.91	-97.04
Total benefit, 2006 prices	3,157	843	904	1,006
Discounted value of total benefit	1,339	138	57	30

Source: Author's calculations.

Across the measures of project worth, expanding the time horizon improves the evaluation of irrigation investment only for the IRR, which increases to – 5.1 percent, from – 42 percent (Figure 9). The reason is that extending the time horizon allows for a more extended period in which positive returns are accruing to the project. However, the ratio of benefits to costs falls slightly down to 24 percent, from 26 percent under ex-post assessment. Lastly, the NPV falls further to Php -55 billion, as extending the benefit horizon is simply unable to balance the full investment cost incurred in 2008 – 2016.

Figure 10: Measures of project worth, irrigation investments, ex-ante and ex-post, 2008 – 2045



Source: Author's calculations.

4.3 Ex-post and ex-ante, 2008 – 2045, fixed loss in irrigated area

We conduct a sensitivity analysis in which AMPLE is only applied to generate baseline prices; incremental output uses a fixed estimate of the change in irrigated area in the counterfactual, equal to the cumulative irrigated area for 2008-2016. Incremental returns are now much higher than in the previous ex-post and ex-ante analysis, as it rules out endogenous adjustment of the agricultural market to a shock in irrigated area. Incremental output ranges from Php 8 billion to Php 8.4 billion by 2045. In 2006 prices and discounted to present value, the total benefits range from Php 2.5 billion in 2017, falling to just Php 0.2 billion by 2045.

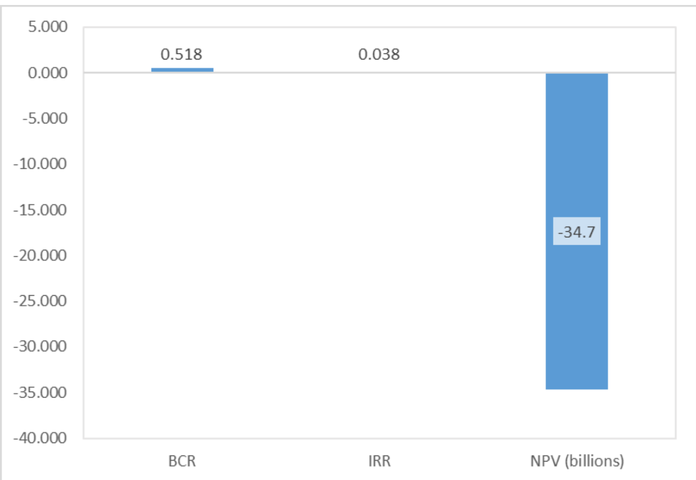
Table 5: Palay output and price, projections for 2017 to 2045, in Php millions

	2017	2027	2037	2045
Incremental returns	8,071	7,946	8,089	8,356
Difference in cost (Php per ton)	-861	-861	-861	-861
Incremental cost	-381	-381	-381	-381
Total benefit, 2006 prices	5,870	5,783	5,882	6,068
Discounted value of total benefit	2,489	946	371	178

Source: Author's calculations.

Measures of project worth for the fixed irrigated area counterfactual are shown in Figure 10. With higher benefit estimates from 2017 onward, the IRR rises to positive values, reaching 4 percent. However, it remains far below the hurdle rate of 10 percent. Likewise, the BCR rises to 51.8 percent, but remains far below the cut-off of 100 percent. Finally, the NPV rises to Php -35 billion, compared to Php -55 billion in the previous analysis. However, society continues to incur significant loss by over-investment in irrigation.

Figure 11: Measures of project worth, irrigation investments, ex-ante and ex-post, 2008 – 2045



Source: Author's calculations.

5. Conclusion

Rice policy in the Philippines has been undergoing dramatic shifts in recent years. In trade policy, the state has reversed decades of self-sufficiency targeting to accede to its international trade obligations by converting non-tariff barriers into equivalent tariffs. In rice industry development, the latest Draft of the Rice Industry Roadmap (DA, 2018) continues to target import substitution, but subject to a cost-plus margin, i.e. 35 percent tariff protection but free trade otherwise. Income of rice farmers is targeted to increase by 50 percent by 2022. The Roadmap adopts a strategy of irrigation development focusing on priority medium-yield provinces (Table 6), with percent irrigated area harvested below the national average.

Table 6: Priority medium yield provinces of the Philippines

Low cost	Medium cost
Agusan del Norte	Bohol
Aklan	Compostella Valley
Albay	Ifugao
Antique	Negros Oriental
Camarines Sur	Occidental Mindoro
Capiz	Quezon
Cavite	
Iloilo	
Lanao del Sur	
Leyte	
Maguindanao	
Masbate	
Negros Occidental	
Palawan	
Sorsogon	
South Cotabato	
Surigao del Sur	
Western Samar	

Note: In the Philippines, medium-yield provinces have an average yield of 3 to 4 tons per ha. Priority medium-yield provinces are into provinces with low cost (below Php 12 per kg) and medium cost (Php 12 to Php 17 per kg).

Source: DA (2018).

Despite these recent shifts, budget allocation for irrigation appears to follow a different set of priorities, i.e. as if the previous regime of production targeting and self-suffficiency remain intact. This leads to expenditure allocations sustaining the levels observed since around 2011, i.e. Php thirty billion or greater. Such allocations are justified in terms of the benefits, although a proper evalaution of these investment is to systematically compare benefits to costs.

This study has conducted this systematic comparison for investments undertaken in 2008 – 2016. The analysis adopts various assessment frames to arrive at a more robust set of conclusions about the resurgent irrigation program. Across all frames, the findings converge around the following: **Costs of irrigation investment are too large in comparison with expected benefits**. None of the project worth indicators reach threshold levels: rather, the BCR tends to fall below unity; IRR estimates tend to fall below the hurdle rate of 10 percent; and estimated NPV tend to fall below zero.

These finding are far from original. They simply continue a strand of research on irrigation programs of past decades, which also found that IRR of at the feasibility study stage tend to overestimate actual returns. This is moreover consistent with the findings of the other papers under this PIDS research program, which saw considerable gaps between potential and actual benefits of irrigation.

This begs the question of how irrigation projects gain approval at the feasibility stage. Key informants from NIA have pointed out that actual feasibility studies incorporate non-crop benefits from irrigation, as mentioned in Section 2.1. This highlights a key limitation of our benefit-cost analysis, namely incorporating benefits only from incremental rice output.

It is not the argument of this paper to deny wholesale the validity of the government's policy on investment programming for irrigation. Certainly, there will be any number of irrigation projects, making appropriate assumptions about future crop and non-crop benefits, which will validly reach favourable findings about IRR, BCR, and NPV. This paper argues rather that policy reform abandoning production and self-sufficiency targeting, already underway, be adopted more consistently. The justification for investment planning in terms of reaching some target level of potential irrigation area should be treated greater skepticism. And finally, project evaluation at the feasibility stage must be stricter about making credible projections concerning future crop and non-crop benefits of proposed irrigation projects.

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