Institute of Economic Development and Research
SCHOOL OF ECONOMICS
University of the Philippines

Discussion Paper No. 68-3 February 1, 1968

COMPARATIVE ECONOMIC ANALYSIS OF LOW-LIFT (SURFACE) AND TUBEWELL IRRIGATION PROJECTS IN THE PHILIPPINES

by

Leon A. Mears, 1907-

NOTES: (1) This paper was originally presented at Seminar on Economics of Rice Production, International Rice Research Institute, Los Baños, December 9-10, 1967.

(2) IEDR Discussion Papers are preliminary versions circulated privately to elicit critical comment. References in publications to Discussion Papers should be cleared with the author.

Comparative Economic Analysis

of Low-lift (surface) and Tubewell Irrigation Projects in the Philippines

The current strategy of the Philippine Government to obtain self-sufficiency in rice production gives high priority to increasing technical irrigation potential in rice producing areas.[1] This will permit increased planting of high-yielding seed in the dry season as well as reduce the risk of lower yields from such seed from untimely dry spells during the rainy season. The assured supply of water enables realization of the high yield potential from combining water and fertilizer with the new highly fertilizer-responsive seed. With highly capital intensive inputs (fertilizer together with chemicals to protect against insect losses) required to realize the high production potentials, it is essential that such assured water supply be available to minimize the farmer's risk in making such investment.

This emphasis on rapid increase of irrigation facilities places priority not only on the increase and rehabilitation of large scale gravity systems but also on surface (low-lift) and tubewell pumping of irrigation waters. And, while there has been some summary investigation of the economics of such irrigation, little use has been made of modern methods (which take the time factor into account) to evaluate the profitability of irrigation combined with the new high-yielding seed, or to compare benefits from using either low-lift or tubewell pumps to supply the irrigation water.[2]

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[1] The Rice and Corn Self-sufficiency Program "aims to expand the area under irrigation at least 1,000,000 hectares," Rice and Corn Production Coordinating Council, Four-year Rice and Corn Self-sufficiency Program, 1966-1970, Department of Agriculture and Natural Resources, July 21, 1966, p. 18.

[2] Net benefits of low-lift and pump irrigation are described in a study by Gilbert Levine, but not using present value methods, see "Irrigation Costs in the Philippines," The Philippine Economic Journal, First Semester 1966, pp. 28-41. Rough. estimates are also included for specific gravity projects in Program Imple-

Discounted cost-benefit analysis is applied in this study to two actual small scale irrigation projects on Luzon, one using a low-lift pump, the other a tubewell and pump. The use and shortcomings of such analysis will be illustrated as the economics of these projects are examined from both the social (national) and private investor's points of view, while comparing net benefits from both low-lift and tubewell pump irrigation. Sensitivity analysis will be employed to illustrate the degree to which net benefits will be affected by changes in the price of palay (paddy) to the farmer, in the yield potential and in the rate of adoption of a second crop on the irrigated area.

This study provides comparison of net benefits from using traditional seed and cultivation practices on rainfed paddy fields with those obtained by applying the entire package that combines the new high-yielding seed with fertilizer, irrigation, double cropping, pesticides and weedicides.[3] This study does not indicate the net benefits from irrigation alone. It does illustrate how cost benefit analysis can be used either to establish economic priority between two projects or to determine whether an individual project will generate the economic benefit to warrant its being undertaken. And finally, as a result of this study, it is possible to illustrate the relative importance of irrigation costs, expected yields, price and credit policy on expected benefits from adopting this package of "improved" inputs.

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mentation Agency, Proposal for Financial Assistance for the Irrigation Program of the Philippines, Manila, 1965.

[3] For description of this package, see The International Rice Research Institute, "Cultural Practices for Profitable Rice Production" General Leaflet I, Manila Hotel, March 1, 1967.

Description of the Projects

General details of the two projects are described in the Appendix, Tables I to V. The low-lift pump project covers 60 hectares in Rizal Province. It has just been completed so can be judged only on theoretical grounds. On the other hand, the tubewell project covering 100 hectares in Nueva Ecija Province has been in operation since 1960. Both projects produce palay exclusively. An unusually deep tubewell project (445 feet) was selected to give maximum contrast in comparison with the low-lift source of irrigation water.

Net benefits estimated in 1960 for the tubewell project will be discussed for comparative purposes. However, the major portion of the analysis is based on benefit-cost estimates using 1967 prices and technological possibilities. Thus, the tubewell installation and operating costs have been calculated both on a 1960 and 1967 basis. For 1967, alternative costs have been calculated for two sizes of tubewell pumps; one 1500 G.P.M. (the size originally installed but capable of irrigating not quite half the hectarage in the dry season) and a 3,000 G.P.M. pump capable of fully irrigating the entire 100 hectares in the dry season.[4]

Incremental farm cost estimates were actually slightly different in Rizal than in Nueva Ecija. So, to compare benefits from the package of inputs while using different sources of irrigation water, incremental farm costs with irrigation were assumed to be the same in both projects, with the expected farm costs in Nueva Ecija taken as the standard. Similarly, incremental yields with irrigation

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[4]Hectarage capacities of pumping units as estimated from ISU calculations of "Hectarage Capacity of Pump Units," adjusted for various soil conditions. On the soil existing in both areas, approximately 4 feet of water were considered required each crop season.

were standardized for both regions. In the general case, incremental yields were estimated at 50 cavans per hectare in the wet and 95 cavans per hectare in the dry season. In like fashion, for both projects, similar rates were assumed of second crop adoption after irrigation becomes available. It is further assumed, in the general case, that each year an additional 10 percent of the area potentially irrigable in the dry season is actually second cropped. This assumption is probably conservative under the particular conditions now existing in the Philippines, but experience on this tubewell project and on irrigation projects elsewhere in Asia suggests the assumption may not be too unrealistic.[5]

Thus, holding incremental farm costs and yield plus rate of 2nd crop adoption constant for all three alternative pump projects, comparative net benefits from the package when using the tubewell or the low-lift pumps for irrigation will vary depending on the individual investment, operating and maintenance costs, technical characteristics of the irrigation systems, and methods of financing. As indicated in the tables in the Appendix, methods of financing do vary between the tubewell and low-lift projects. While the low-lift project is benefited by unusually advantageous financing terms arranged by the Agricultural Development Council of Rizal (ACDR), the tubewell project reflects current financing policies of the Irrigation Service Unit (ISU). Where important, the differential effects of these two methods of financing are taken into account.

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[5]For example, five years after irrigation water was first supplied to the primary canals, second cropping had been adopted on less than 25 percent of the area of the Ganges-Kobadak Project in East Pakistan. (Unpublished study of the author.) The tubewell project in Nueva Ecija was completed in 1961 but it was not until 1966 that any rice crop was planted in the dry season (in three prior years, mongo beans had been planted during the second crop but never on over half the area irrigable). In 1966, the sixth year that irrigation water had been available, 38 hectares were second cropped in rice and in 1967 the total was 45 hectares (close to the estimated pump capacity).

[illegible] Case (Discounting at 8%, Palay Price ₱17/cavan, Incremental Yield -- Wet Season 50 cavans/hectare, Dry Season 95 cavans/ hectare)

Assuming a social time preference rate of 8 percent, the comparative economic desirability of the three alternatives are shown on Table 1.[6] With positive present values in all cases, it is evident that net benefits would accrue to either the private farmers or the nation from undertaking any of the alternative projects.[7] The present value is higher for the larger pump, given the greater investment and larger area involved. This measure thus is useful to indicate project benefits *per se* but cannot be used for setting priorities for use of scarce capital except when similar-sized investments are involved.

It is interesting that all projects show a higher present value of net benefits from the national point of view than from the farmers' point of view.[8] Also, if the palay price had been ₱12/cavan rather than ₱17/cavan, the projects would have shown a negative present value from the farmers' viewpoint but a positive one from the nation's viewpoint. (See Table 2 and Graphs 1 and 2.) Such cases can arise. Under varying circumstances, a project might show a positive present value from the national viewpoint and a negative one from the private view-

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[6] This would be the "time preference" rate from the farmers' point of view.

[7] This assumes that the discount rate used corresponds to the actual social and individual time preference rates. The selection of this 8 percent rate for the general case was arbitrary and is probably slightly below the actual values, could they be determined. However, this makes little difference in any of the comparative analysis to follow as the present value of the net benefit flow remains highly positive for discount rates as high as 50% (national point of view) and 100% for the farmers' point of view.

[8] This arises with the elimination of transfer payments from the costs from the national viewpoint, which more than offsets the earlier inclusion of capital costs see Appendix, Tables VI and VII for illustrative examples of these calculations.

TABLE 1

Comparative Economic Desirability of Projects According to Different Criteria[1]

	Farmers' Viewpoint			National Viewpoint		
	Low-lift Pump	Tubewells 1500GPM Pump	Tubewells 3000GPM Pump	Low-lift Pump	Tubewells 1500GPM Pump	Tubewells 3000GPM Pump
1. Present Value of Net Benefit Flow (₱000)	143.2	201.3	281.5	172.9	251.4	333.6
2. Benefit Cost Ratio	1.345	1.32	1.345	1.45	1.43	1.45
3. PV'/K [2]	72.6	16.2	19.4	28.4	4.71	4.93
4. Internal Rate of Return (%)	540	148	141	245	60	53

[1] Assumed conditions:
- Palay price to farmer ₱17/cavan
- Incremental yield from "package" of inputs, in cavans/hectare: wet season 50, dry season 95
- Incremental farm costs as shown in Table V, Appendix
- 10% of potential area of second cropping added yearly
- Costs and other details as indicated in Tables III and IV, Appendix
- Rate of discount for criteria 1,2,3 is 8%.

[2] PV' = Present value of net benefit flows not including capital cost (assumed to fall due in pre-operative period)

K = Capital cost (i.e. opportunity cost of resources committed in pre-operative period)

PV'/K is shown in ₱ of Present Value (not including capital cost) per unit of capital cost as defined above.

TABLE 2

Comparison of Project Benefits
with Different Palay Price to the Farmer [1]

Palay Price to Farmer/cavan	12		17		20	
	Present Value of Net Benefit Flow (₱000)	IRR[2] (%)	Present Value of Net Benefit Flow (₱000)	IRR[2] (%)	Present Value of Net Benefit Flow (₱000)	IRR[2] (%)
Farmers' Viewpoint						
Low-lift pump project	- 20	neg.	143	540	241	500+
Tubewell 1500 GPM project	- 44	neg.	201	148	347	275
Tubewell 3000 GPM project	- 41	neg.	281	141	477	235
National Viewpoint						
Low-lift pump project	10.2	19	173	245	270	420
Tubewell 1500 GPM project	6.4	10	251	60	398	80
Tubewell 3000 GPM project	19.6	12	334	53	537	73

[1] Assume conditions:

Incremental costs, benefits and other details as described in Tables III to V, Appendix .

Incremental yields from "package" of inputs, in cavans/ hectare Wet Season 50, Dry Season 95.

10% of potential area of second cropping added yearly.

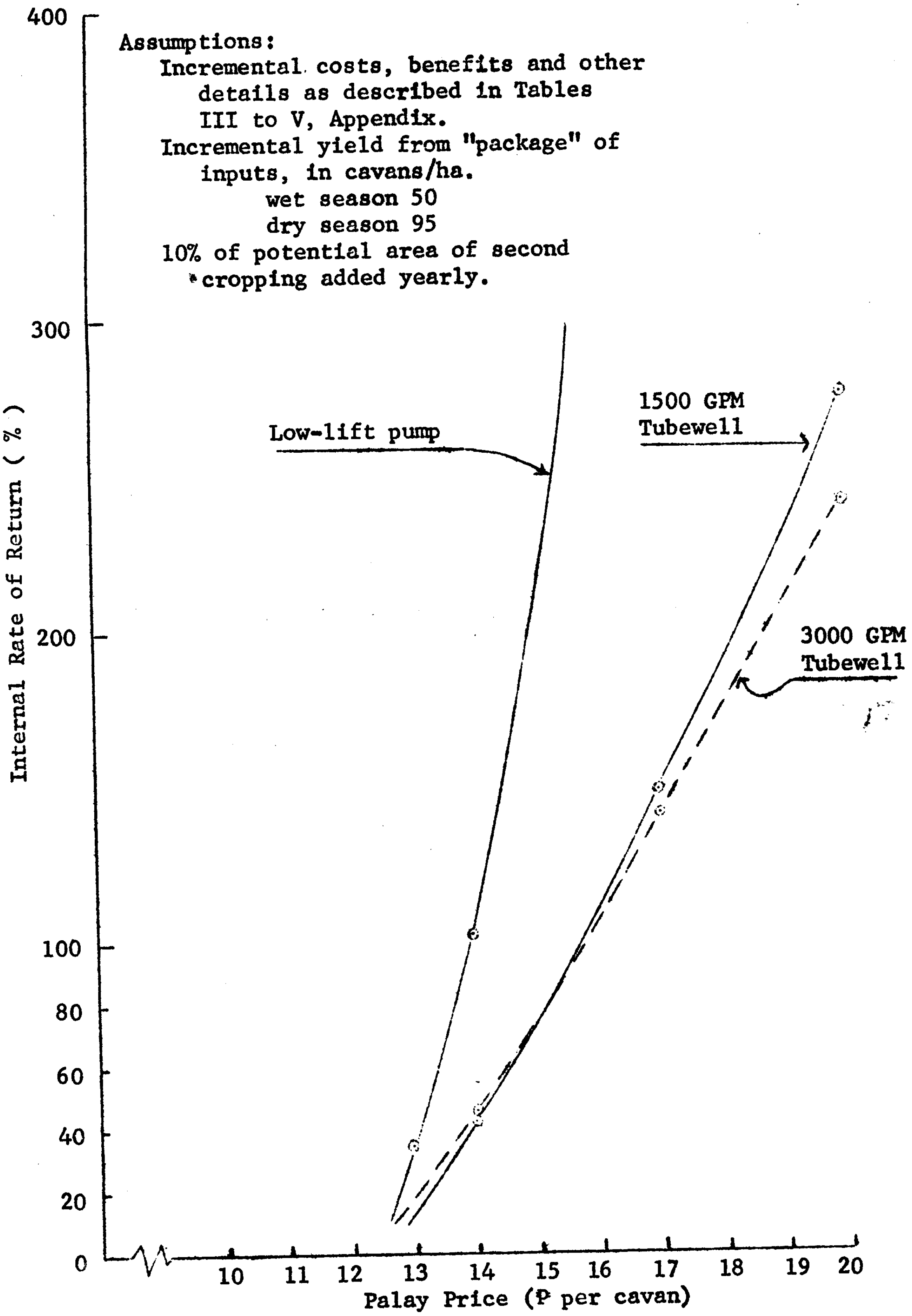
Rate of discount 8%.

[2] IRR = Internal Rate of Return· neg. = negative.

Graph 1

Internal Rate of Return as Farm Palay Price Varies

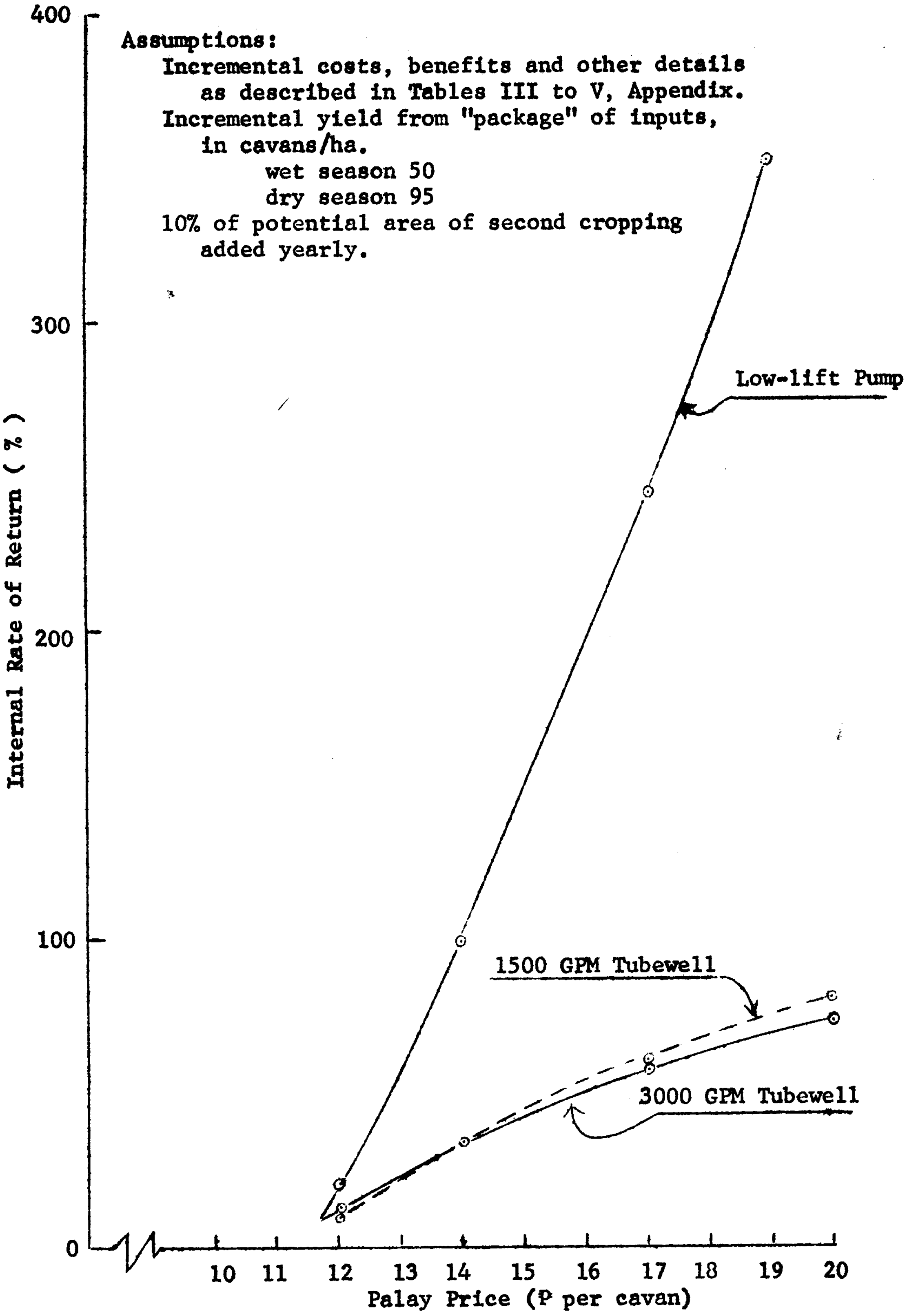
(Farmers' Viewpoint)



Graph 2

Internal Rate of Return as Farm Palay Price Varies

(National Viewpoint)



point, or the opposite might be true. This is why it is important for a government planner to know the present value from both points of view. [If the net benefits to the private investor are too low to induce desired investment, while the net benefits from the national viewpoint are relatively high, subsidies or tax relief might be warranted. And in the opposite situation, where the nation might suffer a net welfare loss while the private investor would realize a net benefit, government control to conserve scarce resources can take the form of credit constraints or more direct deterrents.] However, as far as the irrigation projects under analysis are concerned, rates of return are high from the private investors' viewpoint and even existing subsidies might be reduced or eliminated without affecting investment.

The other three criteria shown in Table 1 are ones frequently used for determining project priorities under the conditions usually existing in developing countries where capital availability constraints must be satisfied. As all three criteria /benefit/cost (B/C) ratio, internal rate of return (IRR) and Present Value -- not including original investment -- per unit of original investment (PV'/K)/ show different relationships, it is not surprising that their individual usefulness might differ and that they might not always provide similar ranking of projects.[9] For example, while from both the farmers' and national points of view the IRR and PV'/K criteria indicate strong priority for the low-lift pump, the B/C ratio shows no difference between the low-lift and the 3,000 G.P.M. tubewell projects. This illustrates the difficulty in ranking with a ratio such as the B/C ratio.[10]

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[9] For a discussion of the precise differences between these criteria, see Joseph L. Tryon and F.E. Cookson, A Critical Survey of Project Planning, Center for Development Planning, National Planning Association, Washington, 1966, pp. 52 ff.

[10] For a complete discussion of the dangers of using ratios as indicators of importance, see Roland N. McKean, Efficiency in Government Through Systems Analysis, New York, John Wiley & Sons, 1958.

While the IRR and PV'/K both give highest priority to the low-lift pump project, their respective priorities for the other two projects differ.[11] In these later projects, which are mutually exclusive, the IRR becomes a hazardous criterion to use for selection decisions. For example, by reference to Graph 1, it will be seen that as the palay price is varied, the IRR changes, with project priorities reversing as the IRR reaches the lower range which is more likely to include the actual time preference rates. In this instance, the priority given to the two projects reverses as the IRR drops below approximately 42% return.

This difficulty must be weighed against a different problem arising with the use of PV'/K. The precision of this criterion depends on the ability to determine the social time preference rate (s.t.p. rate) for the economy and the time preference rate of the individual. The latter might be determined by questioning the individual and is apt to relate closely to the interest rate at which the individual can borrow money for financing the project. However, with no certain determination of the s.t.p. rate, arbitrary selection of a discount rate adds to the uncertainty that project selection by the PV'/K criterion will actually result in an optimum social welfare solution. For this reason, certain international financing agencies are reportedly relying increasingly on the IRR as an investment priority criterion.[12] Even in such cases, other criteria are used as checks against the IRR, with project priorities more secure to the extent confirmed by other criteria. And, in using the IRR, its limitations must be remembered. If the estimated IRR is relatively high on

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[11] See Tryon, op.cit., pp. 152 ff. for discussion of reasons for these different results.

[12] Recent discussion with economists of the IBRD suggest that the IRR has become one of the principle tests of economic profitability used by the World Bank.

mutually exclusive projects, their relative priority should definitely be confirmed by other criteria such as PV'/K.[13]

Effect on Net Benefits of Variations in Product Prices, Expected Production Yields, Input Prices, Rates of 2nd Crop Adoption and Methods of Financing

Net Benefits as Product Prices Varied. Graphs 1 through 4 illustrate the high level of net benefits on all three projects that would accrue both to the country and the farmer if the palay price received by the farmer were held at ₱16/cavan of palay. In both 1967 and 1968, the floor price that the Rice and Corn Administration (RCA) attempted to maintain for the farmer was not lower than ₱16 in any region and in some regions was as high as ₱17/cavan. Thus, as long as incremental yields were realized as have been premised for the general case, any of the three projects would have proven highly beneficial in any area where rainfall did not provide a consistent two-season water supply and where other water sources were available for pumping.

As evident from the graphs, the net return per unit of investment would be appreciably higher for the low-lift pump than for the alternative projects. This would be expected with the higher costs of deep-well drilling and more expensive pumping costs. Low-lift pumps, with their lower capital and operating costs, have been found profitable for rice cultivation in the Philippines even with lower yielding seed varieties. However, there has been a scarcity of studies examining the profitability of tubewell projects. If the results of this study are borne out by

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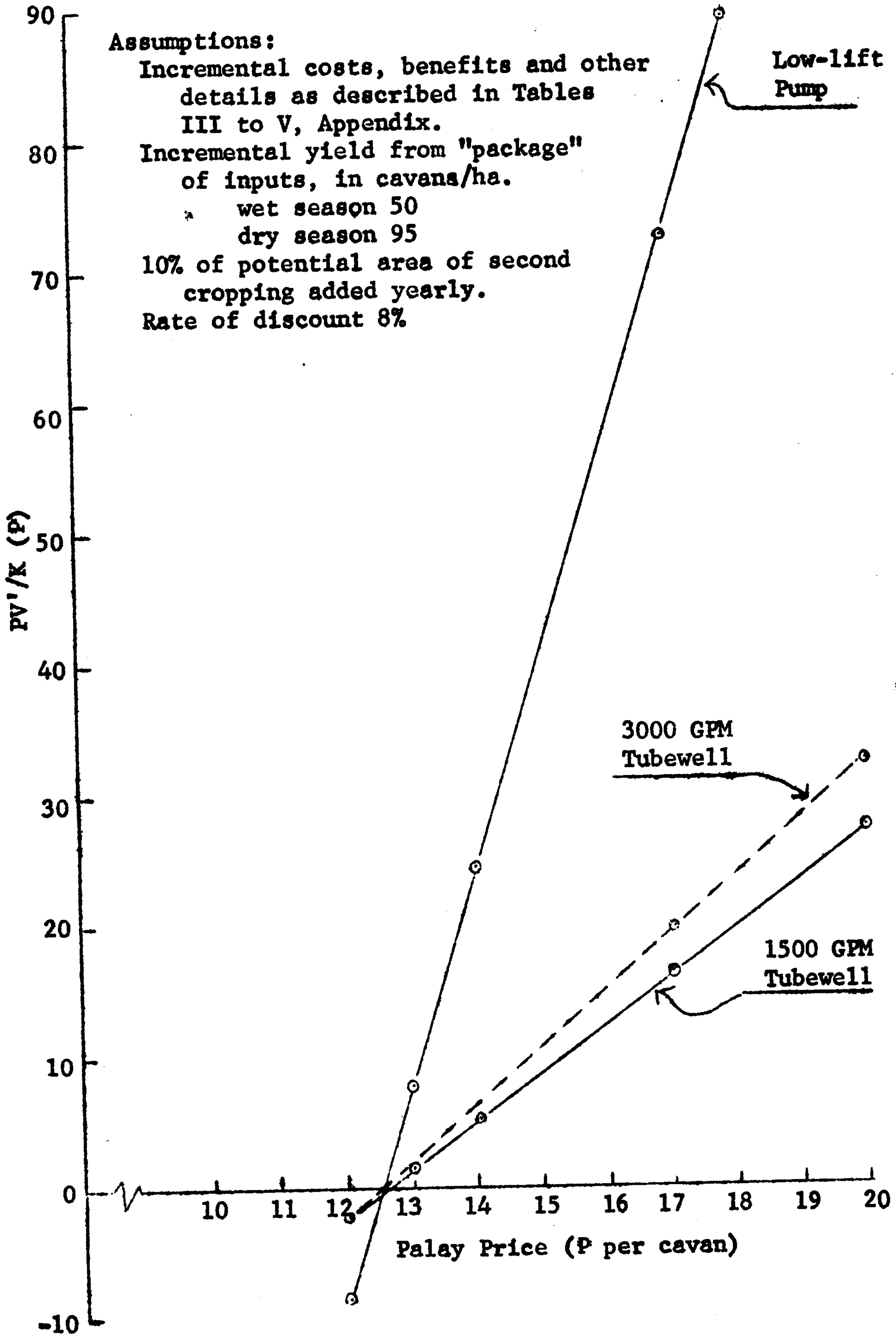
[13] In some instances, the use of different discount rates within the probable s.t.p. range makes little if any difference in the priority given the projects. In such cases, much greater reliance can be placed upon the PV'/K criterion.

Graph 3

PV'/K as Farm Palay Price Varies

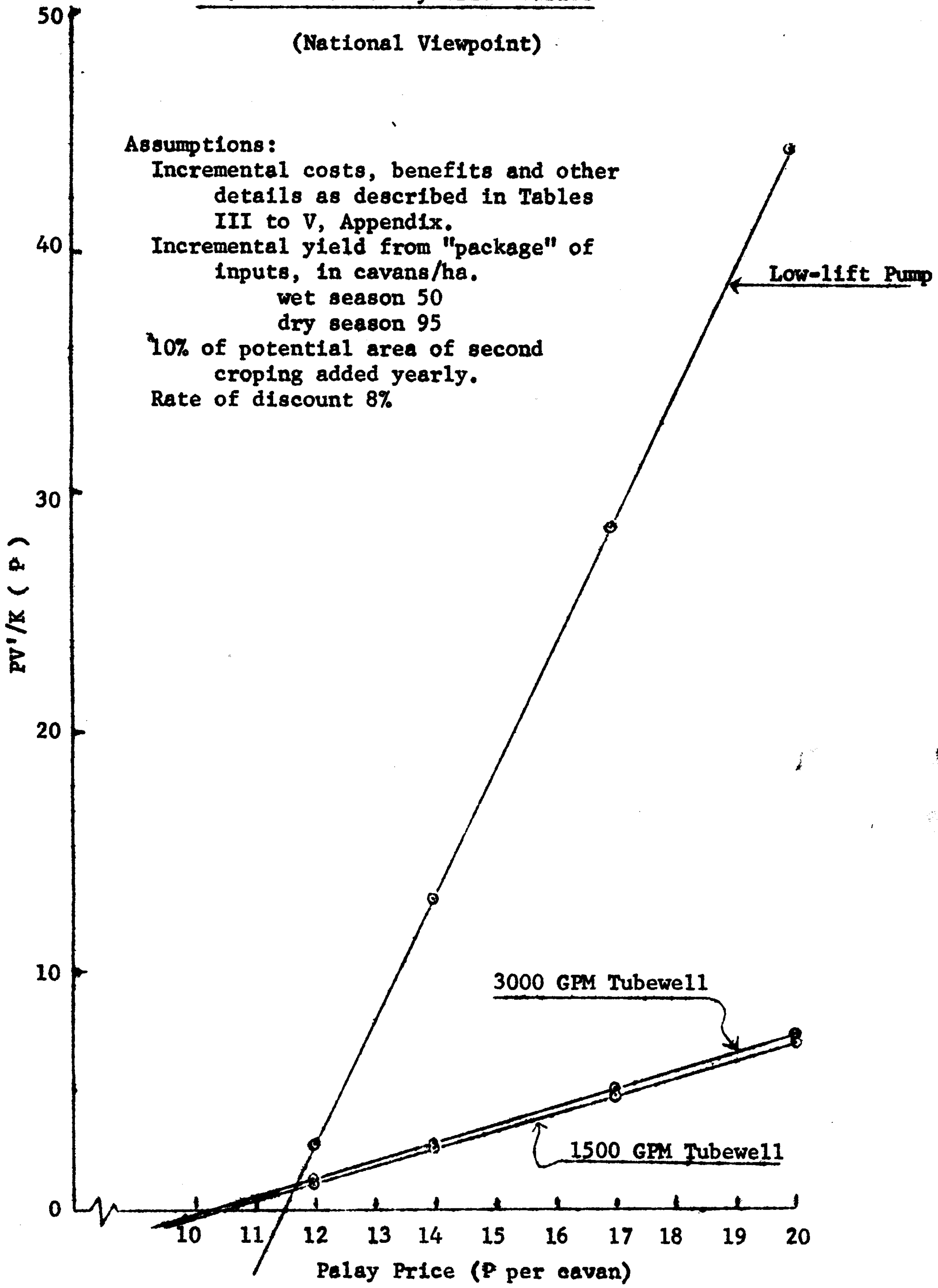
(Farmers' Viewpoint)



Graph 4

PV'/K as Farm Palay Price Varies

(National Viewpoint)



further investigations and the author sees no reason why they should not be, then the irrigation authorities can proceed with confidence in promoting irrigation for high yield varieties of rice both from low-lift and tubewell pumping. However, it must be remembered that tubewell pumping will continue to have a risk that is not present with low-lift surface pumping. Until underground water resource surveys have been made, there is always risk of inability to obtain adequate water from a given well.[14] Also, if surface water is available for gravity irrigation or for pumping, these methods appear generally preferable to tubewell water sources.

Net Benefits as Expected Yields Vary. The advantage of the high yielding seed now available in the Philippines is strikingly illustrated by the comparative project benefits as expected yield is varied, see Table 3. None of the projects would have shown net benefits to the farmer if the expected incremental yield had been as low as 30 cavans per hectare in the wet season and 75 cavans per hectare in the dry season, incremental yields that would have been exceptional with traditional seed. From the national viewpoint, only the large tubewell project would have shown net benefits at such a low yield increment. However, it will be seen that with a yield increase of 50 cavans/hectare in the wet season and 95 in the dry season, extremely high internal rates of return would be realized.[15]

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[14]The ISU reports that they as yet have not designed a single 3000 G.P.M. pump for operation on one well as they do not have sufficient experience with the aquifier to have confidence that such a flow could be maintained.

[15]These incremental yields appear to be conservative in relationship to actual experience with the high yielding varieties when used with the entire "package" of inputs. For example, in the rainy season in Central Luzon in 1967, the RCPCC reported yield on almost 14,000 hectares of IR-8 harvested by the end of October as averaging 112 cavans/hectare, "Progress Report on the Rice and Corn Program," Manila, November 28, 1967 (mimeographed).

TABLE 3

Comparison of Project Benefits with Different Incremental Yields[1]

Incremental Yields: (cavans/ha.)	Wet Season / Dry Season	30 / 75			50 / 95			65 / 125		
		IRR[2]	B/C Ratio	PV'/K	IRR	B/C Ratio	PV'/K	IRR	B/C Ratio	PV'/K
Farmers' Viewpoint										
Low-lift pump project		neg.	(0.91)	- 18	540	(1.35)	72.6	500+	(1.76)	157
Tubewell 1500 GPM project		neg.	(0.88)	- 5	148	(1.32)	16.2	375	(1.72)	35.5
Tubewell 3000 GPM project		neg.	(0.93)	- 2.5	141	(1.34)	19.4	340	(1.75)	41.6
National Viewpoint										
Low-lift pump project		neg.	(0.98)	- 0.25	245	(1.45)	28.4	500+	(1.90)	55.3
Tubewell 1500 GPM project		neg.	(0.95)	0.58	60	(1.43)	4.71	101	(1.87)	8.5
Tubewell 3000 GPM project		9	(1.01)	1.08	53	(1.45)	4.93	92	(1.89)	8.8

[1]Assumed conditions:

Palay price to farmer ₱17/cavan
Incremental costs and benefits as shown in Tables III to V, Appendix
10% of potential area of second cropping added yearly
Rate of discount for B/C ratio and PV'/K = 8% .

2 neg. = negative.

These high IRR are confusing in the sense that they are not comparable with IRR from projects from other sectors of the economy or from other types of agricultural projects. The fertilizer applied is calculated as a cost while it is at the same time an important capital input. Thus, by not including it with capital costs, the IRR for the package is somewhat overstated. But, even an IRR of half the magnitude of those shown in Table 3 would make the projects appear most attractive economically. The highest incremental yield level, 65 cavans per hectare in the wet season and 125 in the dry season, that is shown is well within the range of possibilities according to reports and gives almost fantastically high benefits.[16] For example, with the 1500 G.P.M. tubewell project, after covering all added fertilizer and other costs, from the national viewpoint the fixed capital cost is covered 8 1/2 times in terms of present value of net benefits (see criterion PV'/K = 8.5).

Table 3 also illustrates the care that must be taken in using the different project criteria. The benefit cost ratios as absolute numbers, for example, can be given no precise interpretation. As can be seen, at the medium incremental yield basis from the national viewpoint, the low-lift pump project appears to be much more beneficial than the other projects by both the IRR and PV'/K criteria, but by the benefit cost ratios, the low-lift pump and 3,000 G.P.M. tubewell projects both appear equally beneficial. Also, while the 1500 G.P.M. tubewell project seems to be more beneficial than the larger tubewell pump project when appraised by IRR, the reverse is true when the PV'/K criterion is used.

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[16]For example, see farm yield data as reported by Randolph Barker, "Costs and Returns in Rice Production," International Rice Research Institute Seminar paper, October 7, 1967, and Barker and E.U. Quintana, "Farm Management Studies of Costs and Returns in Rice Production," Seminar International Rice Research Institute, December 9, 1967 (mimeographed).

<u>Ne[illegible] Adoption Varies</u>. As already indicated, a conservat[illegible] of second cropping has been assumed for the general case studied.[17] Second cropping may not be necessary to justify a project, but benefits do change appreciably depending upon the second cropping practice followed. For example, with other conditions the same as in the general case, the 3,000 G.P.M. tubewell project (farmers' viewpoint) would show a PV'/K of 30.4 if all the area were second cropped starting with the first year of the project -- in contrast to a PV'/K of only 19.4 if only 10 percent of the potential second crop area were added annually. The reverse holds true if no second crop is planted. For example, as indicated in Table 4 for the 1500 G.P.M. tubewell project, all criteria show a decided decline in benefits when only one crop is planted. However, the farmer might be willing to invest in pump irrigation even though incremental yields did not provide sufficient benefits to cover capital and incremental operating costs providing the risk of complete crop loss without irrigation was considered high. However, a positive supply of water might assure some level of income above zero each year, even though the average annual income level would decline.

This seems to have been the approximate situation at the tubewell project when it was first installed in 1960. The farmers reported that they had experienced several years of complete loss from drought. They thus were willing to contract for the tubewell even though the project -- given the low incremental yields expected at that time -- would show a net loss unless second cropping was

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[17] 10 percent of the potential area for second cropping added yearly. For example, with the 3,000 G.P.M. tubewell pump, the total area could be irrigated in the dry season with this water flow. Thus 300 hectares additional second croppi[ng] is added yearly, with the entire project area second cropped at the end of the 10th year.

TABLE 4

Comparison of Project Benefits with and without 2nd Cropping [1]
(Tubewell 1500 GPM Pump Project)

	No Second Crop			10% of Potential Second Crop Area Added Annually		
	PV'/K	IRR	B/C Ratio	PV'/K	IRR	B/C Ratio
Farmers' Viewpoint	8.3	120	1.21	16.2	148	1.32
National Viewpoint	3.1	42	1.32	4.71	60	1.43

[1] Assumed Conditions:

Palay price to farmer ₱17/cavan
Incremental farm costs as shown in Table V, Appendix
Costs and other details as indicated in Tables III and IV, Appendix
Rate of discount for B/C ratio and PV'/K = 8%
Incremental yield from package of inputs, in cavans/hectare:
wet season 50; dry season 95.

adopted [illegible] assumed in our general case.[18] With only minor second [illegible] vegetables actually taking place, it was hardly to be expected that the farmers could maintain loan repayments.[19] And, it was not until the high-yielding rice varieties became available in 1966/67 that any appreciable second cropping took place. By that time, the incremental yield potential had more than doubled, apparently providing the required incentive to elicit the added effort.[20]

Net Benefits as Other Input Prices Vary. Prices of inputs other than irrigation water -- such as fertilizer -- can likewise affect the level of benefits and the attractiveness of investing in the total "high yield" package. These exact cost benefit relationships have not been examined in this study because they have not been of critical importance in the Philippines in recent years. However, it is well to keep in mind the importance of the price of fertilizer, a major input cost. For example, in 1967 in Indonesia, with fertilizer prices at world market levels but rice highly subsidized below world market levels, the farmer had no inducement to invest in the high-yield package while net benefits to him would be negative. At the same time, from the national point of view, net benefit levels were high.[21] At

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[18] If 10% of the potential area of second cropping had been added annually, the present value of net benefit flows would have been negative, the B/C ratio 0.97, and PV/K 0.7.

[19] The contract with ISU was re-negotiated in 1964 at much more favorable terms.

[20] It is also interesting to note that the variety IR-8 had not been used in this project area for the first crop because of fear of high water levels. Since 1966/67, IR-8 has been planted as a second crop (with average yield of 93 cavans/ha) and starting in 1967/68, high yielding BPI-76 has been used for the wet season crop.

[21] For discussion of this experience, see Leon Mears, "Strategy for Increasing Food Grain Production in South and Southeast Asia," to be published in The Philippine Economic Journal, First Semester 1967, Vol. VI, No. 1.

such times, if relative prices cannot be rationalized, changes in the subsidy pattern are required if the increases in yield from using the high-yield package are to be realized.

Net Benefits to Farmers as Financing Methods Varied. Comparison of benefits from the farmers' point of view using mainly external financing or entirely own funds is illustrated by reference to Table 5. With payment by the farmer for fixed capital delayed by external financing, the project looks appreciably more beneficial to him than it would had he been forced to pay his own funds at the start of the project. Thus, the internal rate of return is 3 times as large and PV'/K four times as large with external as compared to own-fund financing. This illustrates another tool of policy makers, who can vary the amount of financing to increase the net benefits and thus help to induce the investor to increased activity on projects in strategic sectors. Special financing arrangements are frequently important solely because the farmers do not have funds of their own or acceptable collateral to obtain loans through normal banking channels. However, it is important to remember that special financing arrangements can also serve a second purpose, that of making the investment appear economically more attractive than if he had used his own funds.

Irrigation Investment and Operating Costs. Comparative investment and annual irrigation costs per hectare are summarized on Table 6. It will be noticed that the annual irrigation costs per crop range from ₱56 to ₱134 per hectare. These rates are extremely high compared to new increased rates of the National Irrigation Administration, still not put into effect in all areas, of ₱25/hectare for the first

TABLE 5

Comparison of Project Benefits from Different Methods of Financing as Seen from Farmers' Viewpoint[1]
(Tubewell 1500 GPM Pump Project)

Source of Funds for Fixed Capital Investment	PV'/K	IRR	B/C Ratio
ISU Financing Procedures[2]	16.2	148	1.32
Farmers' own funds entirely[3]	3.7	48	1.33

[1] Palay price, incremental costs and yields as in general case, see Table 3.

[2] Farmers own funds for canals and structures only ₱8,000.
10 year loans for balance, from ISU and rural bank ₱ 67,300.

[3] Farmer financed by own funds ₱75,300.

TABLE 6

Comparative Investment and Annual Irrigation Costs
(assuming 2nd crop on all potentially irrigable area)
(pesos/hectare)

	Low-lift Project	Tubewell Project		
		1500 GPM		3000 GPM
	1967	1960	1967	1967
Area potentially irrigable (2 crops) (hectares)	100	147	147	200
Capital investment,[1] plus interest charges as indicated in project studies	17	43	50	48
Operation and maintenance	39	51	80	86
Total annual irrigation cost/hectare[2]	56	95	130	134
Investment cost (excluding interest) per hectare[2]	128	265	512	491

[1]Amortized over expected life.

[2]per crop hectare; counting each actual hectare of land as 2 hectares when double cropped.

rice crop and ₱35/hectare for the second rice crop.[22] But even at the high rates for these projects, investment in the package -- including irrigation -- appears to be extremely beneficial both to the private farmers and to the nation. Thus, there would appear to be no reason why farmers should not be willing to pay these new charges, or even higher charges, where it was practical to plant the new high yielding varieties and the "package" of other inputs could be financed.

It is evident from Table 6 that the total investment cost, excluding interest charges, is much less for the low-lift pump project than for the tubewells. This is as would be expected but it emphasizes a point made above that tubewell pumping should not be considered in areas where adequate surface water is available. The investment costs for the low-lift pumps are not only lower than those for the tubewells but also are lower than average costs of gravity systems constructed by the National Irrigation Administration. Levine points out that it is logical that the Philippines should currently anticipate costs for such works approximately ₱1,000 per hectare (single cropped), or ₱500/hectare if sufficient to provide complete double cropping.[23] These figures compare closely with the costs on the tubewell projects studied as well as on recent Philippine project proposals.[24] Thus, to the extent that low-lift pump projects are feasible, it would appear that the expansion of the irrigated land can be effected at one-quarter the cost of either tubewells or large gravity systems.

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[22]Board of Directors, National Irrigation Administration, Resolution No. 12-64, dated, September 18, 1964.

[23]Op. cit., pp. 30-31.

[24]Investment costs per cropped hectare were estimated at ₱760 for the Dummon River Irrigation Project and ₱550 for the M'Lang River Irrigation Project, see Presidential Economic Staff, Project Studies, Dummon River and M'Lang River Irrigation Projects, Manila, 1967.

Financing to cover the investment to provide irrigation for an additional 1,000,000 hectares will apparently total somewhere between ₱125,000,000 and ₱500,000,000, but probably a greater amount of financing will be needed annually for production loans to cover the incremental cash costs associated with using the "package" of high-yielding inputs with the new seed and irrigation. On the basis of incremental costs as now estimated, financing for the second crop on an additional 500,000 hectares would come to ₱200,000,000. These will be seasonal demands, with almost as much being required for the first crop./

Summary and Conclusions

The present study comparing the discounted costs and benefits of low-lift pump and tubewell irrigation projects associated with the use of the package of high yielding inputs is based on an extremely small sample to permit any firm generalizations. However, even though costs and benefits will vary with particular situations, it is unlikely that the general conclusions of this paper will be negated with further study.

Aside from illustrating the use and limitations of time oriented investment criteria, certain substantive conclusions also can be made. While irrigation may be more cheaply provided by low-lift pumps, it would appear that tubewells can be expected to show a high rate of return both to the private investor and to the economy when the water is used together with the "package" of high yielding inputs with new fertilizer-responsive varieties of rice. Of course, this would not be true where adequate underground water resources were lacking. There would thus seem to be a high priority for rapidly surveying underground water resources in areas where adequate surface water is not available so the benefits therefrom could be tapped with a minimum of risk.

It was shown that benefits may and usually will differ depending on the point of view involved. Thus, there could be national advantage in certain situations to provide subsidies to stimulate the private sector in strategic activities (where benefits are high from the national viewpoint but appear low to farmers). At present, it may be important to maintain the existing relatively high floor price for palay to stimulate farmers to invest in irrigation and the package of high yielding inputs along with improved seed. However, as self-sufficiency is reached, this policy could well be re-evaluated. With the high profit potential as found, it is likely that production levels would continue to expand even after decreasing interest charge subsidies or high support prices. Further, as the net benefits of an irrigation project increase rapidly as the adoption rate of second-cropping is speeded up, it might pay big dividends to direct extension efforts towards stimulating rapid adoption on irrigated land where this is not occurring.

Farmers and landlords included in this study all shared incremental costs and returns so there were not differential benefits for the two groups. For many other project areas this would probably not follow. Further study is needed to determine the differential benefits to tenants and landlords under various arrangements that might be found in practice in the Philippines.

APPENDIX

TABLE I

General Project Information
Tubewell Project

Location: Paruket, Quezon, Nueva Ecija

Irrigation Project of Irrigation Service Unit (ISU)

ISU provided free supervision for installation

First operations: January 1960

Description of Project: Turbine type deep well pump with diesel engine
10" 1500 G.P.M. 105 H.P. Engine

Depth of Well: 445 feet
120 feet 16 inch casing
210 feet 14 inch casing
120 feet 10 inch casing

Surface Soil: Sandy loam
Area to be irrigated: 100 hectare (not subject to flooding but water level during rainy season may rise higher than IR-8 variety for extended periods.
Crop: Rice, 1 crop before irrigation (average yield 35 cavans/hectare)
2 crops expected after irrigation.
Area accessible by motor vehicle.

Project operated by: Irrigation Association, Inc.

1 regular member (landlord)
20 special members (tenants)

Crop Seasons: Wet: May/November
Dry: December/April

Other Deepwells in Vicinity:

1 - 6 inch and 1 - 8 inch within 5 kilometers.

APPENDIX

TABLE II

General Project Information
Low-lift Pump Project

Location: Bilibiran, Binangonan, Rizal

Irrigation Project of Agricultural Development Council for Rizal which provides supervision for irrigation.

First Operations: Wet Season 1967.

Description of Project: Low-lift pump with engine
8" 1200 G.P.M. 25.5 H.P. Engine

Soil Surface: Sandy loam
Area to be irrigated: 60 hectares, not subject to flooding.
Crop: Rice, 1 crop before irrigation (Average yield 50 cavans/hectare)
2 crops expected after irrigation.
Area accessible by motor vehicle.

Project operated by: Tagpos Farmer's Association
30 regular members (owner-operators)

Crop Seasons:
Wet: May/November
Dry: December/April

Source of Water: Bilibiran Creek, running into Laguna de Bay approximately 1/2 kilometer from project. Creek also used for irrigation by other farmers upstream. Stream flow test, August 1966, 1656 liters/second.

APPENDIX

TABLE III

Investment and Operating Data - Tubewell

Part A. Direct Benefits; Value of Added Increment of Production

		Yield/hectare	Hectares cropped	Production: Quantity in cavans	Production: Value in pesos
(a) 1960 - Farm palay price ₱8.00/cavan					
Rainfall - no irrigation	1st crop	35	100	3,500	28,000
Irrigated (same seed and cultivation practices)	1st crop	45	100	4,500	36,000
	2nd crop[1]	45	47	2,115	16,920
Net annual increment in value[2]					24,920
(b) 1967 - Farm palay price ₱17.00/cavan					
Rainfall - no irrigation	1st crop	35	100	3,500	59,500
Irrigated - high yielding seed & inputs	1st crop	85	100	8,500	144,500
1500 GPM pump	2nd crop[1]	95	47	4,465	75,905
3000 GPM pump	2nd crop[2]	95	100	9,500	161,500
Net annual increment in value 1500 GPM pump					160,905
Net annual increment in value 3000 GPM pump					246,500

Part B. Current Farm Costs (including sales taxes and labor at market prices)
Increment in farm costs (see Table V, this table, for cost details)

	Cost/ha. (₱) Season: Wet	Cost/ha. (₱) Season: Dry	Ha. cropped Season: Wet	Ha. cropped Season: Dry	Total Cost (₱)
(a) 1960 - no fertilizer or insecticides					
Farm costs - irrigated[1]	177	177	100	47	26,019
Farm costs - rainfed	163		100		16,300
Annual increment in costs					9,719

(b) 1967 - Fertilizer and insecticides on irrigated crops

Farm costs - irrigated - 3000 GPM pump[2]	795	855	100	100	165,000
Farm costs - irrigated - 1500 GPM pump[2]	795	855	100	47	119,685
Farm costs - rainfed	273		100		27,300
Annual increment in costs - 3000 GPM pump					137,700
Annual increment in costs - 1500 GPM pump					92,385

Part C. Operation and Maintenance Costs of Irrigation Works - per year

	Wet Season		Dry Season		Total Cost (₱)	
	1500 GPM	3000 GPM	1500 GPM	3000 GPM	1500 GPM	3000 GPM
(a) 1960[1]						
Number of days	60		90			
Fuel, oil and grease costs (₱)	2,100		3,150		5,250	
Labor (mechanic/watertender) costs (₱)	250		250		500	
Maintenance and repair - Equipment (10% landed cost)					1,435	
Maintenance and repair - Canals and structures (5% of cost)					310	
Total					₱7,495	
(b) 1967[1]						
Number of days	60	30	90	90		
Fuel, oil and grease costs (₱)	2,400	2,400	3,600	7,200	6,000	9,600
Labor (mechanic/watertender) costs (₱)	750	1,000	750	1,000	1,500	2,000
Maintenance and repair - Equipment (10% landed cost)					3,860	5,250
Maintenance and repair - Canals and structures (5% of cost)					400	400
Total					₱11,760	17,250

TABLE III--Continued, page 3

Part D. Cost of Equipment and Construction (in ₱)

	10" - 1500 GPM Pump		16" - 3000 GPM Pump
	1960 Prices (actual cost)[3]	1967 Prices (estimates)[4]	1967 Prices (estimates)[4]
(a) Engine and pump	14,345	38,600	52,500
(b) Casing and drive shoes	4,929	10,800	15,000
(c) Arrestre	212	300	400
(d) Compensating tax (7% of items 1-2-3)	1,364	3,600	4,750
(e) Drilling and well development	11,855	14,000	17,500
(f) Structures and canals	6,200	8,000	8,000
Total	38,905	75,300	98,150

Part E. Financing

1960 -- Structures and canals -- own funds ₱ 6,200
Balance of construction and equipment -- 10 year amortization -- ₱ 3,270.50/year[5]

1967 --

	1500 GPM Pump	3000 GPM Pump
Structures and canals -- own funds	8,000	8,000
Engine, pump, casing, drive shoes, arrestre and compensating tax, 10 year amortization, per year (ISU loan)[5]	5,330	7,265
Drilling and well equipment - (Rural Bank Loan) principal, per year[6]	1,400	1,750
interest - 12%/yr on outstanding balance[6]		
1st year	1,680	2,100
2nd year	1,510	1,890
3rd year	1,340	1,680
4th year	1,180	1,470
5th year	1,010	1,260
6th year	840	1,050
7th year	670	840

8th year	500	630
9th year	340	420
10th year	170	210

Production Loan (Rural Bank) assumes 6 months loan in both wet and dry season on incremental cash farm costs. Interest - 12%/year. Total interest per year [illegible] planting second crop on maximum hectarage permitted by pump:
₱4,434 when using 3000 GPM pump and ₱3,234 for 1500 GPM pump, pay[illegible] end of year.
Total loan: 3000 GPM pump, wet season ₱33,900; dry season ₱39,990;
1500 GPM pump, wet season ₱33,900; dry season ₱18,753.

Part F. Other Costs

Increment in Sales tax on fertilizer and insecticides[7]: wet - crop ₱20/ha.; dry - crop [illegible]
Shadow price adjustment for labor
Reduction in incremental unskilled labor costs, not including transplanters and harvesters (50%) ₱25/ha.

Part G. Life of Equipment and Structures

Pumps and engines	10 years
Balance	15 years

(Salvage value at end of 10 years: 3000 GPM Project ₱14,050; 1500 GPM Project ₱10,950)

Footnotes:
1 Maximum hectarage of pump at full capacity for clay loam = 47 ha. in dry season
2 Assuming all farmers plant a second crop to extent water available
3 Imported items duty free in accordance with existing agreement with USAID
4 Includes duty of 10% (on C.I.F. cost) 1500 GPM Pump ₱4,500; 3000 GPM Pump ₱6,250
5 No interest unless payment not made in advance, then 1/2% per month plus surety bond requirement (ISU Loan).
6 Payments at end of year, Rural Bank Loan.
7 Included in total farm costs on Table V.

APPENDIX

TABLE IV

Investment and Operating Data -- Low-lift Pump

Part A. Direct Benefits; Value of Added Increment of Production -- Farm Palay Price ₱17.00/cavan

		Yield/hectare	Hectares cropped	Production: Quantity in cavans	Production: Value in pesos
Rainfall -- no irrigation -- traditional seed and cultivation practices	1st crop	35	60	2,100	35,700
Irrigated -- high yielding seed and inputs	1st crop	85	60	5,100	86,700
	2nd crop	95	40	3,800	64,600
Net annual increment in value, when farmers plant second crop on 40 hectares					115,600

Part B. Current Farm Costs (including sales taxes and labor at market prices)

Increment of farm costs	Cost/ha (₱) Season: Wet	Cost/ha (₱) Season: Dry	Ha. cropped Season: Wet	Ha. cropped Season: Dry	Total Cost (₱)
Fertilizer and insecticides on irrigated crops					
Farm Costs -- irrigated, high yielding seed and inputs	795	855	60	40	81,900
Farm Costs -- traditional seed and cultivation practices	273		60		16,380
Net Annual Increment in Costs, when farmers plant second crop on 40 hectares					65,520

Appendix - Table IV, page 2

Part C. Operation and Maintenance Costs of Irrigation Works - per year
(assuming farmers plant second crop on 40 hectares)

	Wet Season	Dry Season	Total [illegible]
Number of days	60	90	
Fuel, oil and grease costs (₱) @ ₱7.50/day	450	675	1,[illegible]
Labor (mechanic/watertender) costs (₱) @ ₱12/day	720	1,080	1,[illegible]
Maintenance and repair -- Equipment (10% landed cost)			79[illegible]
Maintenance and repair -- Canals and structures (5% of cost)			19[illegible]
Total annual cost			3,909

Part D. Cost of Equipment and Construction (in ₱)

(a) Engine and pump	7,905.00	
Cost of installation	1,000.00	8,905.00
(b) Construction costs		
Pump and engine foundation	400.00	
Engine House	1,000.00	
Stilting pool	300.00	
Sump, wooden, 600 board feet @ P0.50/bd. ft.	300.00	
Canals: 1,000 linear meters, 1,500 cu. meters @ ₱1.00/cu. mtr.	1,500.00	
Contingencies, 10%	350.00	3,850.00
Total		12,755.00

Part E. Financing

(a) Machinery and Construction Loan - Rural Bank

Special terms arranged by ADCR -- 8% interest for 10 years
Both principal and interest payments at end of year

Amount of Loan	₱11,480
Down Payment on Machinery and Construction Costs by Farmers' Association	1,275
Total cost of machinery and construction	12,755

Annual principal payments ₱1,148

Interest payments:

1st year	₱918	6th year	₱459
2nd year	827	7th year	367
3rd year	734	8th year	276
4th year	643	9th year	184
5th year	551	10th year	92

(b) Production Loan - Rural Bank - Interest 1%/month, payable at end of year. Wet and dry season loans assume to each be for 6 months in amount of needed incremental cash farm costs.
Total interest/year when farmers plant second crop on maximum hectarage permitted by pump: ₱2,178.
Total Loan: Wet season ₱20,340; Dry Season ₱15,960.

(c) Machinery portion of Rural Bank Loan (financed by Central Bank Loan received from IBRD).
Amount of Loan: ₱6,000 (CIF foreign exchange cost of pump and engine).
Terms: 10 years at 5 3/4% interest plus 3/4% annual carrying charge.
Annual principal payments: ₱600.

Interest payments:

1st year	₱390	6th year	₱195
2nd year	351	7th year	156
3rd year	312	8th year	117
4th year	273	9th year	78
5th year	234	10th year	39

(d) Investment Summary
From National Point of View:

Total fixed capital		₱12,755
Less: Foreign Loan	₱6,000	
Duty & sales tax on pump and engine	855	6,855

Net contribution	₱5,900
From Farmers' point of view:	
Capital paid in to Farmers' Association	2,000

Part F. Other Costs (in ₱)

(a) Increment in sales tax on fertilizer and insecticides (included in farm costs on Table V) — Wet crop 20/ha.; Dry crop 24/ha.

(b) Shadow price adjustment for labor
Reduction in incremental unskilled labor costs (which are not taken to include transplanters and harvestors), 50% reduction — 25/ha.

(c) Taxes paid on pump and engine: (Duty @ 5% ₱300; Sales Tax @ 7% ₱555) — 855

(d) Annual administrative expenses of Farmers' Association for collection of dues, operation and maintenance — 6,000

(e) Annual administrative expense of ACDR; Cost per hectare (This expense assumed to last for only 5 years) — 16/ha.

Part G. Life of Equipment and Structures

Pumps and engines	10 years
Structures and canals	15 years
(Salvage value at end of 10 years ₱1,283)	

APPENDIX

TABLE V

Cost of Farm Inputs, with and without Irrigation
(Tubewell and Low-lift Pump Projects)
(pesos/hectare)

	Rainfed	
	Own labor and carabao	Cash payments
I. 1960 (Palay ₱8/cavan)		
Seeds		10
Labor and carabao[2]	72	
Labor only[3]	19	20
Harvesting and threshing[4]		
Total - 1960	91	30
II. 1967 (wet season) (Palay ₱17/cavan)		
Seeds[5]		20
Fertilizer[6]		
Insecticides and weedicides[6]		
Labor and carabao[2]	108	
Labor only[3]	25	30
Harvesting and threshing[4]		
Total - wet season - 1967	133	50
III. 1967 (dry season) (Palay ₱17/cavan)		
Seeds[5]		
Fertilizer[6]		
Insecticides and weedicides[6]		
Labor and carabao[2]		
Labor only[3]		
Harvesting and threshing[4]		
Total - dry season - 1967		

Footnotes: [1]No fertilizer or other chemicals used for rainfed cultivation. Costs not included: land tax, capital investment (land, equipment and buildings).

[2]Labor plus carabao cost imputed at ₱6/day.

[3]Labor cost imputed at ₱3/day.

[4]Harvesting and threshing in kind @ 15% of crop.

TABLE V--Continued

Cultivation[1]		Irrigated Cultivation			
Payments in kind	Total	Own labor and carabao	Cash payments	Payments in kind	Total
			10		
		72			
		21	20		
42				54	
42	163	93	30	54	177
			25		
			84		
			220		
		126[7]			
		63	60[8]		
90				217	
90	273	189	389	217	79[illegible]
			25		
			144		
			220		
		126[7]			
		63	60[8]		
				217	
		189	449	217	855

[5]1967-regular variety seeds with rainfed high fertilizer responsive variety (IR8) with irrigated cultivation.

[6]Fertilizer and chemicals for weed and insect control approximately as perscribed by International Rice Research Institute, General Leaflet #1, March 1, 1967.

[7]Improved seed bed preparation and increased harrowing when using irrigation.

[8]Straight row planting after using irrigation.

APPENDIX

TABLE VI

Net Benefit Flow from Farmers' Viewpoint 1967
1500 GPM Pump -- Assuming Farmers Adopt Second Cropping Gradually
Discount Rate 8% -- Values in ₱
Incremental Yield from "Package" of Inputs, in cavans/hectare:
Wet Season 50, Dry Season 95
Palay Price ₱17.00/cavan 1/

Year:	Pre-operational	1	2
Direct Benefits			
Incremental benefits[1]		93,075	101,150
Undepreciated structures			
Current Costs			
Incremental farm costs[1]		56,475	60,750
Operation and maintenance - irrigation		8,560	8,960
Structures and canals	8,000		
Loan - Irrigation Service Unit			
Pump, casing and accessories	5,330	5,330	5,330
Loan - Rural Bank - drilling			
Principal		1,400	1,400
Interest		1,680	1,510
Loan - Rural Bank - production			
Interest		2,154	2,274
	13,330	75,599	80,224

[1]Assumes 5 hectares of 2nd crop added 1st to 9th year and 2 hectares in 10th year. Incremental costs and other assumptions as indicated in Tables III and V, Appendix.

TABLE VI--Continued

3	4	5	6	7	8	9	10
109,225	117,300	125,375	133,450	141,525	149,600	157,675	160,905 10,950 171,855
65,025	69,300	73,575	77,850	82,125	86,400	90,675	92,385
9,360	9,760	10,160	10,560	10,960	11,360	11,560	11,760
5,330	5,330	5,330	5,330	5,330	5,330	5,330	
1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400
1,340	1,180	1,010	840	670	500	340	1[illegible]0
2,394	2,514	2,634	2,754	2,874	2,994	3,114	3,234
84,849	89,484	94,109	98,734	103,359	107,984	112,419	108,949

Total Discounted Benefits	837,600
Less Discounted Costs	623,000
	214,600
Less pre-operational expense	13,300
Present Value of Net Benefit Flows	201,300

$$\text{Benefit/Cost Ratio} = \frac{837,600}{623,000 + 13,300} = 1.32$$

APPENDIX

TABLE VII

Net Benefit Flow from National Viewpoint 1967
3000 GPM Pump -- Assuming Farmers Adopt Second Cropping Gradually
Discount Rate 8% -- Values in ₱
Incremental Yield from "Package" of Inputs, in cavans/hectare;
Wet Season 50, Dry Season 95[1/]
Palay Price ₱17.00/cavan

Year:	Pre-operational	1	2
Direct Benefits			
Incremental benefits[1]		101,150	117,300
Undepreciated structures			
Current Costs			
Incremental farm costs[1]		60,750	69,300
Operation and maintenance - irrigation		10,770	11,490
Structures and canals and equipment	87,525		
Less			
Labor Shadow price		2,750	3,000
Sales tax increment		2,240	2,480
	87,525	66,530	75,310

[1]Assumes 10 hectares of 2nd crop added each year. Incremental costs, and other assumptions as indicated in Tables III and V, Appendix.

TABLE VII--Continued

3	4	5	6	7	8	9	10
133,450	149,600	165,750	181,900	198,050	214,[illegible]00	230,350	2[illegible]6,500
							14,425
							260,925
77,850	86,400	94,950	103,500	112,050	120,600	129,150	137,700
12,210	12,930	13,650	14,370	15,090	15,810	16,530	17,250
3,250	3,500	3,750	4,000	4,250	4,500	4,750	5,000
2,720	2,960	3,200	3,440	3,680	3,920	4,160	4,400
84,090	92,870	101,650	110,430	119,210	127,990	136,770	145,550

Total Discounted Benefits	1,105,500
Less Discounted Costs	674,400
	431,100
Less pre-operational expenses	87,500
Present Value of Net Benefit Flows	343,600

$$\text{Benefit/Cost Ratio} = \frac{1,105,500}{674,400 + 87,500} = 1.45$$