

Economics of Drip Irrigation Adoption Among Sugarcane Growers: A Farm-Level Cost-Benefit Analysis

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ABSTRACT

Drip irrigation is widely promoted to sugarcane growers as a way to save water and raise returns, and farm-level cost-benefit studies are often cited in support. This narrative review asks how far such studies can be trusted to tell an individual grower whether adoption pays. It draws on published work on sugarcane water relations, on irrigation efficiency and water use, on the economics of technology adoption, on discounting, and on the methods used to estimate effects from observational farm data. No new cost-benefit analysis was carried out and no cost or yield figures are reported. The review finds that the verdict of a farm-level account depends heavily on a small set of choices: the discount rate and horizon, whether subsidies are counted as a transfer or a resource cost, how water and power are priced, farm size, and the yield the grower would have obtained anyway. Adopters are also not a random sample of growers, so a simple comparison with non-adopters tends to mix the effect of the technology with the advantages of the farms that choose it. Water saved on the farm may not be water saved in the basin. The review concludes that adoption can pay under identifiable conditions, that claims of general profitability are poorly supported, and it sets out how accounts should be reported so that readers can judge transfer to their own farms.

Keywords: Drip irrigation; Sugarcane; Technology adoption; Cost-benefit analysis; Discount rate; Irrigation subsidy; Selection bias; Narrative review

Citation: Nyberg, Cavalieri and Seabra [2019]. Economics of Drip Irrigation Adoption Among Sugarcane Growers: A Farm-Level Cost-Benefit Analysis. DOI: 10.62649/v7.i02.2019.pp9-18

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Article Information: Received: September 12, 2018 Accepted: January 23, 2019 Published: May 10, 2019

Article Class: Review Article

1. Introduction

Sugarcane is a long-duration, high-biomass crop that stays in the field for most of a year and, in many regions, returns for further ratoon crops. It uses a great deal of water, and where rainfall is short or poorly timed, irrigation decides whether the crop is grown at all [1, 2]. Water is also becoming harder to secure. Competing demands, a changing climate and falling groundwater tables in

several of the major cane-growing regions all push growers and policymakers towards methods that promise more crop from each unit of water [3, 4, 5].

Drip irrigation is the most frequently proposed answer. By delivering water close to the root zone through a network of pipes and emitters, it can reduce evaporation, runoff and deep percolation relative to surface methods, and it allows nutrients

to be applied with the water [6, 7]. It has been promoted for smallholders in particular, with low-cost versions designed to fit small plots and limited budgets [8, 9]. For a sugarcane grower, though, the practical question is narrower than the technical one: does the investment pay, and for whom?

Answers in the literature are given as farm-level cost-benefit analyses, which set the costs of installing and running a system against the gains in yield, water, labour and inputs, and report a net present value, a benefit-cost ratio or a payback period. These summaries are persuasive because they are single numbers. They are also fragile. The same field, the same equipment and the same crop can give a clearly positive or a clearly negative result depending on the discount rate, the treatment of the subsidy, the price charged for water and power, the size of the holding and the yield the grower would have had anyway. Beneath all of this lies a further difficulty: growers who adopt drip are not a random draw from all growers, so comparing them with others mixes the effect of the technology with the advantages of the farms that choose it [10, 11]. A grower reading a published account needs the answer to a plain question: would this have paid on my farm?

This article is a narrative review. It does not present a new cost-benefit analysis and quotes no cost or yield figures. Its purpose is to set out what published work allows one to say about the economics of drip adoption among sugarcane growers, to show which assumptions carry the result, and to propose how accounts should be reported so that a reader can judge whether they transfer to a different farm. The aim is a fair account of what is known and what is merely repeated.

2. Literature Review

2.1 Sugarcane, Water and the Case for Drip

Sugarcane responds to water throughout its growth, but not equally at every stage. Reviews of its water relations describe a crop that is sensitive to deficits during the period of rapid canopy and stalk growth, that can recover from some stress, and whose sugar content is affected by water supply in ways that differ from its effect on cane weight [1]. Because the crop is grown for a long time and, in a ratoon system, for several cycles, the water it uses over the life of a planting is large, and the water footprint of cane is among the larger ones recorded for common field crops [2].

This is the background to the argument for drip. If a surface method wastes a large share of the water

applied, then a method that wastes less should let the same crop be grown with less water, or a larger area be grown with the same water [6, 12]. The argument is sound in principle, but its force depends on how much was being wasted to begin with, on whether the lost water was truly lost to the basin, and on whether the grower can capture the saving as money. These conditions are ones that a cost-benefit account must test and cannot assume. They are examined in the sections that follow.

There is also an agronomic argument that does not rest on the amount of water at all. Applying water in small, frequent doses and delivering nutrients through the same lines can keep the root zone closer to the conditions the crop prefers, and may reduce the swings between too wet and too dry that surface methods produce [7, 13]. Whether that translates into a yield gain on a given farm depends on how well the old method was being managed, which is rarely recorded. This is why the same technology can look excellent in one report and unremarkable in the next.

2.2 What Drip Changes on the Farm

For a grower, adopting drip changes several things at once. Capital is spent at the outset on filters, mains, laterals, fittings and often a pump or a storage tank. Water use, pumping hours and the labour of irrigating all change, and fertiliser practice may change too. Maintenance becomes a regular task, because emitters and filters must be kept clear, and some parts will wear out before the crop cycle ends [6, 7]. The crop itself may respond, through yield or through the timing of harvest.

Efficiency gains at the plot are easy to describe and hard to price. A reduction in the volume applied matters economically only if water has a cost to the grower, either directly or through the energy needed to lift it. A reduction in labour matters only if that labour has an alternative use or a wage. A gain in yield matters in proportion to the price received and to the share of the gain that is due to drip rather than to better management that came with it. Reviews of water productivity make a related point at larger scale: gains per unit of water are not the same thing as gains per hectare, and neither is automatically an economic gain [14, 15].

2.3 Why Growers Adopt, and Why It Complicates the Account

The general literature on agricultural innovation offers a consistent list of factors associated with adoption: the profitability of the new method, the availability of capital and credit, access to

information, the size and quality of the holding, attitudes to risk and the security of tenure [16, 17]. Later reviews stress that these relationships are not constant. The same factor can speed adoption in one setting and slow it in another, and surveys that measure adoption at one point in time often cannot say whether a factor caused adoption or merely accompanied it [18, 19, 20]. Learning from neighbours and from one's own experience is also central, which means that adopters at different dates may differ systematically [21].

Work specific to irrigation technology adds the role of water scarcity and land quality. Choices of irrigation method respond to soil, slope and the cost of water [22], and adoption is shaped by uncertainty in production as well as by expected returns [23]. Studies of micro-irrigation in India, where this has been examined most closely, report that adoption is concentrated among growers who face high water costs or scarcity, who have access to capital or subsidy, and whose crops give a high return per unit of water [24]. Table 1 summarises the main determinants and the complication each one brings to the economic reading.

Table 1. Commonly studied determinants of drip adoption and why each complicates a simple reading.

Determinant	Why it is expected to matter	Complication
Water scarcity	Raises the value of each unit saved [22, 24]	Scarce water is often unpriced to the farmer
Farm size	Fixed costs of design and fitting; scale of capital [16, 18]	Direction differs with credit and tenure
Capital and credit	Upfront cost is large relative to a season's income [17, 19]	Subsidy can substitute for credit
Information and learning	Neighbours' results reduce uncertainty [20, 21]	Early adopters may differ from later ones
Land quality and soil	Gains depend on soil and slope [22, 23]	Also drives yield without drip
Risk and tenure	Insecure tenure shortens the horizon [16, 19]	Hard to measure in surveys

Note: Qualitative summary of themes in the adoption literature; direction of association differs between settings and no effect sizes are given.

The practical consequence is that a cost-benefit result obtained from a sample of adopters cannot be applied to non-adopters without further argument. Those who adopted were, by definition, those for whom adoption looked worthwhile, and that judgement may have drawn on advantages the outside observer cannot see. Read this way, an unimpressive result on one farm is not proof that

the method fails elsewhere.

2.4 Subsidies, Power and the Price of Water

In many countries drip systems are sold with a capital subsidy, and in several the electricity used for pumping is also priced below its cost of supply. The two interact. A capital subsidy lowers the upfront cost the grower must find. A power subsidy lowers the marginal cost of water, and so lowers the value of any saving in volume [24, 25]. Where water is effectively free at the margin, the water-saving argument for drip has no money value to the farmer, and the case must rest on yield, labour or fertiliser.

Subsidies pose a methodological question that is easy to overlook. From the grower's point of view a subsidy is a receipt, and including it raises the return. From the point of view of the economy it is a transfer, and the resources used to produce the equipment are a real cost whoever pays for them. A decision rule that is correct for the farm can therefore be wrong for the public purse, and the reverse. Good practice is to report the account both with and without the subsidy and to say which perspective is being taken; the general guidance on benefit-cost analysis makes the same point about stating the standpoint [26].

2.5 Water Saved on the Farm and Water Used in the Basin

A persistent finding in the water-resources literature is that saving water at the plot does not necessarily save it in the basin. Water that runs off or percolates under a surface method is often reused downstream or recharges an aquifer, and when a more efficient method makes irrigation cheaper or more productive, farmers may expand the area irrigated or grow thirstier crops, so that total consumption can rise [27, 28]. Empirical work on irrigation technology and groundwater has reported outcomes ranging from reduced to increased extraction depending on what farmers did with the efficiency gain [29], and assessments of India's groundwater suggest that gains in efficiency alone are unlikely to halt depletion without limits on use [15, 25].

This matters for the economics in two ways. First, a farm-level account that counts saved water as a benefit is describing a private gain that may have a public cost. Second, if the grower uses the saved water to irrigate more land, as the global water-saving assessments recognise as a likely response [12, 30], then the relevant comparison is no longer the same field with and without drip but a larger enterprise with a different cost structure. Access to groundwater has itself been shown to

matter greatly for rural welfare [31], which is a reason policymakers want to encourage efficient use and a reason they should not assume that efficiency reduces total use.

2.6 Evidence from Other Crops and Regions

Much of what is known about the economics of drip comes from crops other than sugarcane and from settings that differ from those of cane growers. Programmes of low-cost drip for smallholders growing vegetables and other high-value crops have been described as promising for income and food security [8, 9], and syntheses of smallholder irrigation point to real potential for reducing poverty where costs, markets and institutions allow [32]. High-value horticulture differs from cane, however, in the return per unit of water, in the number of crop cycles per year and in the lifespan of equipment relative to the crop. Findings from these settings are best treated as suggestions for what to look for in cane and not as estimates of what will be found.

3. Materials and Methods

3.1 Scope and Question

The review asks one question in two parts: what do published farm-level analyses allow us to conclude about whether drip irrigation pays for sugarcane growers, and which assumptions and design features determine how far such conclusions can be trusted? The question was divided into the points a reader would need answered: what costs and benefits enter the account, how time and the discount rate are handled, how subsidies and water are treated, how the comparison with non-adopters is made, and how the result is reported. None of these steps is difficult, but each one is easy to skip.

3.2 Literature Assembly

The review draws on peer-reviewed work in four areas: the water relations of sugarcane and the performance of irrigation methods; the economics of technology adoption; discounting and benefit-cost method; and the statistical methods used to estimate effects from farm survey data. Sources were chosen for relevance, standing in their field and clarity of method. Work on other crops and regions is used for what it teaches about method and about conditions, and not as evidence of results in sugarcane.

No new cost-benefit analysis was done for this article, and none of the cost, yield or return figures that individual studies report are reproduced here. We did not run a formal systematic search and we do not claim one. The synthesis is narrative, and

the choice of sources reflects the authors' judgement. The practical consequence is that the review is a better guide to what a sound account should contain than to the size of any particular benefit.

3.3 Appraisal Framework

To judge how far an account can be trusted, we asked four questions of the method rather than of the result. Is the horizon stated, and is the discount rate justified and tested at more than one value [33, 34]? Are subsidies, water and power treated openly, with results shown on more than one basis [26]? Is the counterfactual yield stated, and is the comparison group credible given that adopters choose themselves [11, 35]? And is every item of cost and benefit recorded? Table 2 lists the items we looked for.

Table 2. Items to record in a farm-level account of drip irrigation in sugarcane.

Item	What to record	Often omitted?
Design and fitting	Layout, filters, laterals, installation, expected life	Sometimes
Replacement	Parts that wear out within the horizon, tied to the crop cycle [6, 7]	Often
Pumping and power	Hours, tariff, whether subsidised [25]	Often
Water	Volume, source and price actually faced [15, 24]	Often
Labour	Irrigation labour saved, maintenance labour added	Sometimes
Fertiliser	Changes if applied through the system	Rarely stated
Subsidy	Amount, who pays, timing; show results with and without [26]	Sometimes
Yield counterfactual	What the same field would yield under the grower's old method	Very often

Note: The last column gives the authors' reading of how often published accounts leave the item out or fold it into another line.

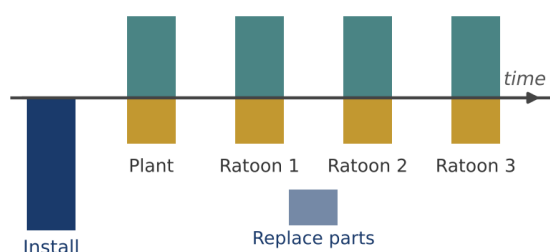
4. Results

4.1 The Anatomy of a Farm-Level Account

A farm-level account of drip irrigation has a recognisable shape, sketched in Figure 1. The largest outlay falls at the start, when the system is designed and installed. Running costs follow each season: power for pumping, maintenance, filters and fertiliser. Some parts wear out before the investment is complete and have to be replaced, and in a ratoon system the life of the equipment relative to the number of cane cycles is one of the central facts of the account [6, 7]. Benefits arrive as the sum of savings in water, power and labour

and any change in cane and sugar value, and they arrive after the costs. Such differences look small in any one season, but they compound over the life of the equipment.

Benefits: water, power, labour, fertiliser, cane and sugar value
Running costs: power, upkeep, filters, inputs



Bar heights are illustrative only; they are not data

Figure 1. Timeline of the cash flows that enter a farm-level account (schematic, not data).

Two features of this shape deserve emphasis. First, because costs come early and benefits late, the value placed on the future decides the outcome, as the next section shows. Second, the account is only as complete as its list of items. The sugarcane literature is clear that yield and sugar content respond to water in complicated ways [1], so benefits should not be reduced to a single yield uplift. Equally, costs should not be limited to the invoice for the equipment.

4.2 Assumptions that Decide the Verdict

Five assumptions recur as the ones that move results most. They are the discount rate and horizon, the treatment of the subsidy, the price of water and power, the size of the holding, and the yield baseline. Figure 2 sketches, qualitatively, how strongly each bears on the cost side and the benefit side of the account. The influence shown is a reading of the literature, not a measurement.

The discount rate is the first of these. Costs come first and benefits later, so a higher rate lowers the present value of the benefit stream more than the cost, and a project that looks attractive at a low rate may look poor at a high one. Choosing the rate is not a technical matter. It reflects the grower's cost of borrowing, the return available elsewhere and views on the future, and there is a substantial literature on how uncertainty about the rate itself should be handled [33, 36]. Allowing for that uncertainty tends to give more weight to the lower rates when the horizon is long [34], and guidance on public projects has moved towards declining rates for distant benefits [37]. For a farm with a limited horizon the more important point is simply that results should be shown at several rates.

Cost side Benefit side

Discount rate and horizon	moderate	larger
Subsidy treatment	larger	smaller
Water and power price	smaller	larger
Farm size	moderate	smaller
Yield baseline	smaller	larger

Qualitative reading of the literature; cells are not measurements

Figure 2. Qualitative influence of key assumptions on the two sides of the account (schematic matrix, not data).

The subsidy is the second. A capital subsidy that covers a large share of the upfront cost can turn a negative account into a positive one without any change in the technology, and a power subsidy can make water-saving worthless to the farmer by making water cheap [24, 25]. Whether the subsidy is counted as a receipt or the equipment at its full cost therefore changes both the sign and the story. Neither choice is wrong, but each answers a different question, and accounts that do not say which they answer cannot be compared. A bank that lends against the equipment will look at exactly this timing, whatever the headline ratio says.

Water pricing interacts with the subsidy. Where water is metered and priced near its scarcity value, each unit saved has a money value and the case for drip is correspondingly stronger; where it is free or charged by area, the saving is invisible to the account [15, 24]. The same technology on two farms facing different prices can therefore give opposite results. Farm size works through scale: design, filtration and fitting have fixed components, so small plots may carry a higher cost per unit area, while larger holdings may face problems of management and water source. The adoption literature does not give a single direction for this relationship [16, 18].

4.3 The Yield Baseline and the Benefit Side

The benefit side depends on the counterfactual: what the same field would have produced under the grower's previous method. Where surface irrigation was poorly timed or applied in excess, a change to well-managed drip can bring a clear gain. Where the old method was already well managed, most of the benefit may lie in saved water, labour and fertiliser, and the gain in cane may be small [1, 13]. Reports that compare drip with a poorly managed baseline will overstate

what drip alone achieves, and ones that compare it with a well-managed baseline may understate what a typical grower would gain.

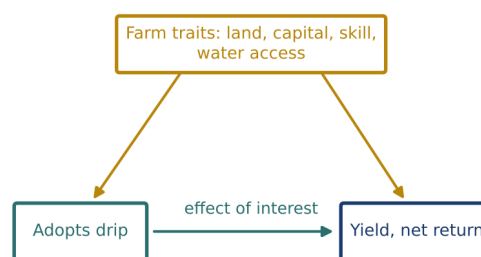
There is also the difference between productivity per hectare and productivity per unit of water. The water productivity literature cautions that large gains are possible in some settings and limited in others, and that the potential is hard to realise without attention to the whole system [14, 15]. For the grower, the relevant measure is the one that matches the scarce input. If land is scarce and water plentiful, return per hectare is the measure; if water is the constraint, return per unit of water matters more, and the use made of the saved water becomes decisive [27, 30]. A saving that disappears once a hired worker's time is priced is not a saving that grower would see.

Timing is a further consideration. Because cane is harvested after a long season, a change in the date of harvest or in the number of ratoons that can be taken profitably alters when benefits arrive, and so their present value. These effects are rarely incorporated in the simple annual comparisons found in the applied literature, where a single season is sometimes made to stand for a decade.

4.4 Adopters Are Not a Random Sample

The most serious design problem in the literature is selection. Growers choose whether to adopt, and the farms that adopt differ from the rest in ways that affect both the decision and the outcome: they may have better land, more capital, closer contact with extension, or more skill [10, 17]. A comparison of the yield or income of adopters and non-adopters then confounds the effect of drip with those prior differences. Figure 3 sketches the problem. A common cause sits behind both adoption and the outcome, so that part of any observed difference would exist even if the technology did nothing.

Statistical methods exist to address this, and they differ in what they can and cannot do (Table 3). Simple comparison of means addresses nothing. Regression with controls handles measured differences. Matching on the probability of adoption balances the observed traits between groups [35], but cannot deal with traits that were not recorded, and its performance depends on the quality of the data and on the care with which it is applied [38]. The broader literature on programme evaluation sets out when each method is credible [39, 40], and it urges caution about claims that any single method settles the matter [41, 42].



Schematic, not data: shared traits can produce a gap even with no effect

Figure 3. Why adopters differ from non-adopters before adoption (schematic causal diagram, not data).

A subtler point is that the benefits of technology may differ across growers, so that those who adopt are those with the most to gain. If so, even a well-identified effect for adopters would overstate what the average non-adopter would gain, and could say little about those who stayed out for good reasons [10]. Evaluations built on roll-outs that are randomised or phased allow cleaner comparison [40], but they are expensive and uncommon in irrigation, and their results are tied to the conditions under which they were run [42]. The point is not that a study is poor, only that its conclusion travels less far than its abstract suggests.

Table 3. Designs used to estimate the effect of adoption and what each leaves open.

Design	What it handles	What it leaves open
Adopter versus non-adopter means	Nothing beyond the raw difference	All differences between farms [11]
Regression with controls	Measured farm traits	Unmeasured skill and land quality [39]
Matching on propensity	Observed traits used to match [35]	Unobserved selection [38]
Before and after on same farms	Fixed farm traits	Season, price and policy shifts
Randomised or phased roll-out	Selection, if well run [40, 41]	Rarely available; limited transfer [42]

Note: Weaknesses are those discussed in the cited methodological literature; they are not attributed to any single study.

4.5 What Published Accounts Leave Open

Putting these strands together, the questions that published accounts most often leave open are the same ones. The yield counterfactual is seldom stated. The discount rate is chosen without a test of other values. The subsidy is blended into the result without showing the unsubsidised case. The price of water is whatever the farmer faces, with no statement of what it would be if it reflected scarcity. And the comparison group is chosen by the farmers themselves.

This does not mean the accounts are wrong. Many of them record real savings and real gains, and in settings with scarce, priced water, good management and access to capital the case for drip can be strong [8, 24]. It means that the number reported is conditional on choices that the reader is not always shown. A positive result on a well-run farm with a high water price is a legitimate finding, but it does not support the claim that drip pays for sugarcane growers in general.

Reports of this kind also tend to be silent on failure. Systems that were installed and later abandoned, or that were run poorly because the grower lacked the skills or supplies to maintain them, rarely appear in the sample, because the sample is made up of those still using the technology. Accounts built only from continuing users can therefore look better than the full experience of those who tried it. Studies that follow adopters and drop-outs over time are rare, but they are needed.

5. Discussion

5.1 Interpretation and Practical Reading

The main finding of this review is conditional. Drip irrigation can pay for sugarcane growers, and the conditions that make it likely are identifiable: water that is scarce and priced, or energy that is costly; a baseline of surface irrigation that is not well managed; access to capital or a subsidy that is available when needed; and a holding on which fixed costs are spread adequately. Where those conditions are absent, a positive account is harder to support. Nothing in this reading argues against drip irrigation; it argues for stating the conditions under which it pays.

The second reading concerns method. The sensitivity of the result to a handful of choices means that single-number summaries should be treated with care. Net present value, benefit-cost ratio and payback each compress the same stream of costs and benefits into a different summary, and each can mislead. A ratio can change depending on whether a saving is classed as a benefit or a negative cost. A payback period ignores everything after the payback date. Where equipment and crop cycles do not match in length, comparison on an annual-equivalent basis is more honest than comparing totals over different periods.

The third reading concerns the distinction between private and public gains. A grower who adopts for private reasons may reduce or increase total water use depending on what is done with the saving [27, 29]. Where the policy aim is to protect

an aquifer, subsidising drip may not achieve it unless accompanied by limits on use [25, 28]. Where the aim is to raise grower incomes, the analysis of subsidy and selection above applies. These points apply with equal force to any capital-intensive farm technology, not only to drip systems.

Three findings would change this reading. A well-designed study with a credible comparison group, showing a sustained gain for typical growers who were not selected for being well placed, would strengthen the general case. An account showing a robust positive result at higher discount rates and without subsidy would settle the question for the conditions in which it was done. And evidence that saved water was in practice used to expand cane area on most adopting farms would shift the discussion from saving water to the economics of expansion.

5.2 Limitations

This is a narrative review and shares the limitations of that form. The selection of sources reflects judgement, no formal search or quality scoring was done, and the review does not quote numerical results from individual sugarcane studies, because these could not be checked against the primary reports for this article. A reader who needs a number should consult the original studies directly, applying the appraisal questions above.

The review also draws heavily on evidence from other crops, other regions and general economic method, and sugarcane-specific economic evidence is thinner than the volume of advisory material suggests. We have used the wider literature to frame what to check and the conclusions should be read in that light. Reviews of this kind are more useful when they say where the evidence stops than when they smooth it over.

5.3 Implications for Reporting

A sound account would state its horizon and the length of life it assumes for each component, show results at several discount rates, and present the case with and without any subsidy [26, 33]. It would price water and power at what the farmer pays and, separately, at an estimate of their scarcity value. It would describe the yield counterfactual and say how it was obtained. It would present best, base and worst scenarios instead of a point, so that the reader can see how far the result moves when the assumptions do.

On the design side, an account that wishes to claim an effect of adoption should say how it handled selection, and should be explicit about

which of the designs in Table 3 it used and what that design leaves open [38, 39]. Samples should include growers who adopted and later abandoned. These requirements are demanding, but they are those that distinguish an account a grower can use from one that supports a hunch.

One practical device is worth singling out. A scenario table with three rows, each a coherent story rather than a random draw, is easier for a grower to read than a probability distribution. A favourable row might assume priced water, a well-timed subsidy and a poorly managed baseline; a base row might assume local prices and average management; an unfavourable row might assume cheap water, delayed subsidy and a well-managed baseline. If drip pays in all three, the case is strong. If it pays only in the first, readers should know that, and the report should say so plainly [14, 34].

5.4 Directions for Future Work

Three needs stand out. First, a formal systematic review of farm-level economic studies of drip in sugarcane, with a transparent search and appraisal, so that the claims made here about the literature can be tested. Second, studies that follow growers over time and across several ratoon cycles, with credible comparison groups. Third, work that connects the farm-level account to the basin, so that the private return and the public cost of water use can be set side by side [12, 28].

5.5 Practical Reading for Growers and Advisers

For an adviser the sensible position is neither to dismiss drip nor to promise returns. A grower weighing adoption can do much with a simple worksheet in the form of Table 2, filled in with own prices, own water source and own records of yield under the present method. Running it with a higher and a lower discount rate and with and without the subsidy takes little time and shows whether the decision is robust or fragile [26, 34].

Such a worksheet does not replace a formal evaluation, and it should not be presented as one. It can nonetheless tell a grower whether the system is likely to be worth pursuing on that farm, and which assumption deserves checking first. The wider question of how much drip adds on average will be answered by designed studies with credible comparison groups and by systematic synthesis of their results [18, 40].

6. Conclusion

Drip irrigation is a plausible investment for sugarcane growers, and under identifiable

conditions it can pay. The evidence, as we can responsibly summarise it, does not support a general claim of profitability. What the literature does show is how sensitive the verdict is to the discount rate, the treatment of subsidies, the price of water and power, farm size and the yield the grower would have had anyway, and how easily a comparison of adopters with others can be distorted by the way growers select themselves. Readers should treat single-number claims with caution until the assumptions behind them are shown.

For the practitioner the message is practical rather than discouraging. Drip can be assessed carefully, provided the account is complete, the assumptions are tested and the subsidy is shown openly. For the researcher the opportunity is a set of long-horizon, well-designed studies in cane that turn a plausible case into a measured one that growers and policymakers can rely on.

7. Acknowledgements

The authors thank colleagues who commented on earlier drafts of this review.

8. Funding

This work received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

9. Conflict of Interest

The authors declare no conflict of interest.

10. Author Contributions

E.N. conceived the review and wrote the sections on irrigation and water use. F.C. wrote the sections on adoption and the economics of subsidies. T.S. wrote the sections on discounting, evaluation design and reporting. All authors revised the manuscript and approved the final version.

11. Ethics Statement

This is a review of published literature. No human participants or animals were involved and no ethical approval was required.

12. Data Availability

No new data were generated. All sources are cited in the reference list.

13. References

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