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FINANCING MINOR IRRIGATION PROJECTS: A DECISION THEORETIC FRAMEWORK TO TACKLE UNCERTAINTIES

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FINANCING MINOR IRRIGATION PROJECTS:

A DECISION THEORETIC FRAMEWORK TO TACKLE UNCERTAINTIES

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Minor irrigation schemes such as the construction of dug wells, dug-cum-bore wells and tubewells form a substantial part of irrigation development in the Fifth Plan. The importance of these schemes can be understood from the fact that six million hectares are to be covered by minor irrigation during the plan period. The major source of water for these schemes is the groundwater (Table 1). It is proposed to construct a cumulative number of 7825 dug wells, 1445 private tubewells and 30 public tubewells by the end of Fifth Plan (Table 2). These are to be spread over larger areas of the country including backward areas and drought prone areas. To support the targets of minor irrigation programme, financial institutions have stepped up their lending. The Agricultural Refinance and Development Corporation (ARDC) has been playing a major role in promoting minor irrigation schemes through the financial institutions (Table 3). One of the important constraints

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in lending for minor irrigation schemes has been the uncertainty associated with the outcome of these loans (because of the problem of failed wells) and the consequent problems of recovery.

Objectives

This paper aims at providing a decision theoretic framework' to tackle the problem of uncertainty in lending for minor irrigation schemes. The framework is illustrated with the help of two examples using data for Mehsana district in Gujarat. The framework is of general interest in dealing with uncertainties in the financing of dug wells, dug-cum-bore wells and tubewells. The framework is simple and required data are easily available. Apart from bankers (including the regional rural banks) the framework can also be used by voluntary agencies in mitigating the hardships of those farmers who fail to strike water.

Uncertainties in lending for minor irrigation schemes

Unlike other types of loans, bankers face uncertainties of a different kind when they sanction loans for minor irrigation schemes. The extension of irrigation programmes over large areas in the country, inadequate data on potentialities of groundwater resources, and other allied technical aspects cause three types of uncertainties:

1) initial failure to strike water at a reasonable depth; 2) failure of wells and tubewells after successful installation; and 3) lack of demand for water in better rainfall years causing deviation from projected revenues. A discussion with the staff of the Directorate of Ground Water Investigation, Ahmedabad brought out several causes for the first two types of uncertainties, some of which are summarized in Table 4.

All these uncertainties affect the repayment of the loan by the borrower and the recovery of loan by the banker. Several steps have been taken by the bankers to minimize the risk in lending for minor irrigation schemes. It has been established, for example, that the demand for tubewell water is negatively correlated with rainfall [3], and, therefore, more of these schemes are sanctioned in areas where rainfall is inadequate. This, however, creates its own uncertainties. The applications for wells and tubewell loans are referred to the departments/directorates of groundwater survey for clearance. These precautions reduce the first type of uncertainties, i.e. failure to strike water. But these measures themselves do not completely eliminate the uncertainties. Further, as there is no restriction on private tubewells constructed by the farmers with their own funds, subsequent failure of wells (after successful installation) are also common, mainly due to lowering of water table. When a well fails, farmers are not in a position to repay loans and bankers experience drastic shortfalls in recoveries.

The incidences of well failure have acquired serious magnitude and have created recovery problems for financial institutions, particularly state land development banks which have been lending in a big way.[1] Studies published so far have, however, mainly concentrated on financial returns, cost-benefits analysis of technical alternatives [1,2,6,9,10,11]. These studies consider the costs and returns from wells and tubewells to be determinate (known with certainty). They, thus, fail to provide guidance to bankers in appraising the loan applications and in devising a workable framework to deal with the problem of failed wells.

Relief Measures

Having recognised the problem of failed wells and hardships and difficulties caused to the cultivators as well as lending agencies, almost all state governments have taken measures to minimize the hardship. These measures differ, however, from state to state. Some have announced a flat rate of subsidy per foot or drilling; others have announced the remission of either total interest, or a part of outstanding loan, or a lump sum subsidy. Still others give subsidy on the basis of water discharged per hour. All these measures, however, provide only partial relief.

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[1] The magnitude of the problem can be understood better from the fact that the Reserve Bank of India constituted a working group with Dr. V.M. Jhakhade as Chairman to look into the problem of failed wells. The report of the Group, however, has not been made public.

The ARDC formulated a novel scheme in 1971. Under this scheme, the risk was to be shared by the farmer, bank, government, and input agencies. A risk stabilization fund was constituted with the lead bank in the district (initially implemented at Raipur District in Madhya Pradesh) and a various parties were to contribute a fixed sum per well. While this idea of risk fund was sound, the contributions from various parties were not determined on a scientific basis (incorporating varying magnitude of risks) which could be applied with modifications to other districts. Subsequent discussion in this paper presents one such framework based on decision theory.

Decision theoretic framework

Recent developments in decision theory assist us in incorporating uncertainty into the analysis and help us to determine the contribution to risk fund per well. If there is more than one contributor, the contribution can be shared. Once contribution is made, those farmers who fail to strike water can be completely exempted from repaying the loan. It also provides a framework for deciding between various alternatives in case of subsequently failed wells.

The anatomy of decision theoretic approach consists of (i) alternatives, (ii) possible events which can take place in case of alternative, (iii) probabilities associated with each possible event in case of each alternative, and (iv) a defined criterion of choice. Broadly the approach to decision theory is (i) to measure the pay-offs from different alternatives given the occurance of various events; (ii) to assess the probabilities of these events happening and (iii) to develop the criterion for choosing between the available alternatives given the probabilities of various events and corresponding pay-offs (4,5,7 and 8). The most widely used criterion for choice is expected monetary value (8). The interactions between various elements are illustrated with the help of two examples.

Example 1: Lending for Tubewells in Mehsana

In the hueristic example, there are two alternatives before the bankers in Mehsana district: (I) finance tubewells on the basis of available information or (II) finance tubewells on the basis of geophysical survey of the proposed site (Figure 1). In the case of both alternatives, two possible events can happen: (i) the borrower may fail to strike water, or (ii) the borrower may succeed in striking water in adequate quantity and quality. Both are mutually exclusive and collectively exhaustive events.

The probabilities associated with the events in alternative I were worked out from the data given in Table 5 which shows the cumulative number of tubewells drilled in Gujarat and those succeeded. Till the end of 1976, 1945 tubewells were drilled and of these 1522 were successful. From these figures, the probability of success comes to 0.78 and probability of failure 0.22.

The probabilities associated with the events in alternative II were worked out on the basis of tubewells drilled and the number of successful wells in Mehsana district (Table 6). It was pointed out by the officials of Directorate of Ground Water Investigation, Ahmedabad that probabilities of success and failure derived from this data are close approximations to the actual situation when testing of site is also done.

The installation cost of tubewell in Mehsana is given in Table 7. In addition, site testing cost has been taken as Rs. 500. This cost, however, varies from district to district depending upon the depth. The depth is taken to be 300 meters.

In the case of failed well under alternative I, the only recovery will be the contribution to risk fund (F) and the government subsidy at the rate of Rs. 65.61 per meter (or Rs. 20 per foot) on the total depth of the well (D) against the drilling cost of Rs. 60,000 (or Rs. 300 per meter). In case of successful wells, loan advanced is Rs. 1,23,500. In this case, recovery is made of the entire amount and the contribution to risk fund (Figure 1).

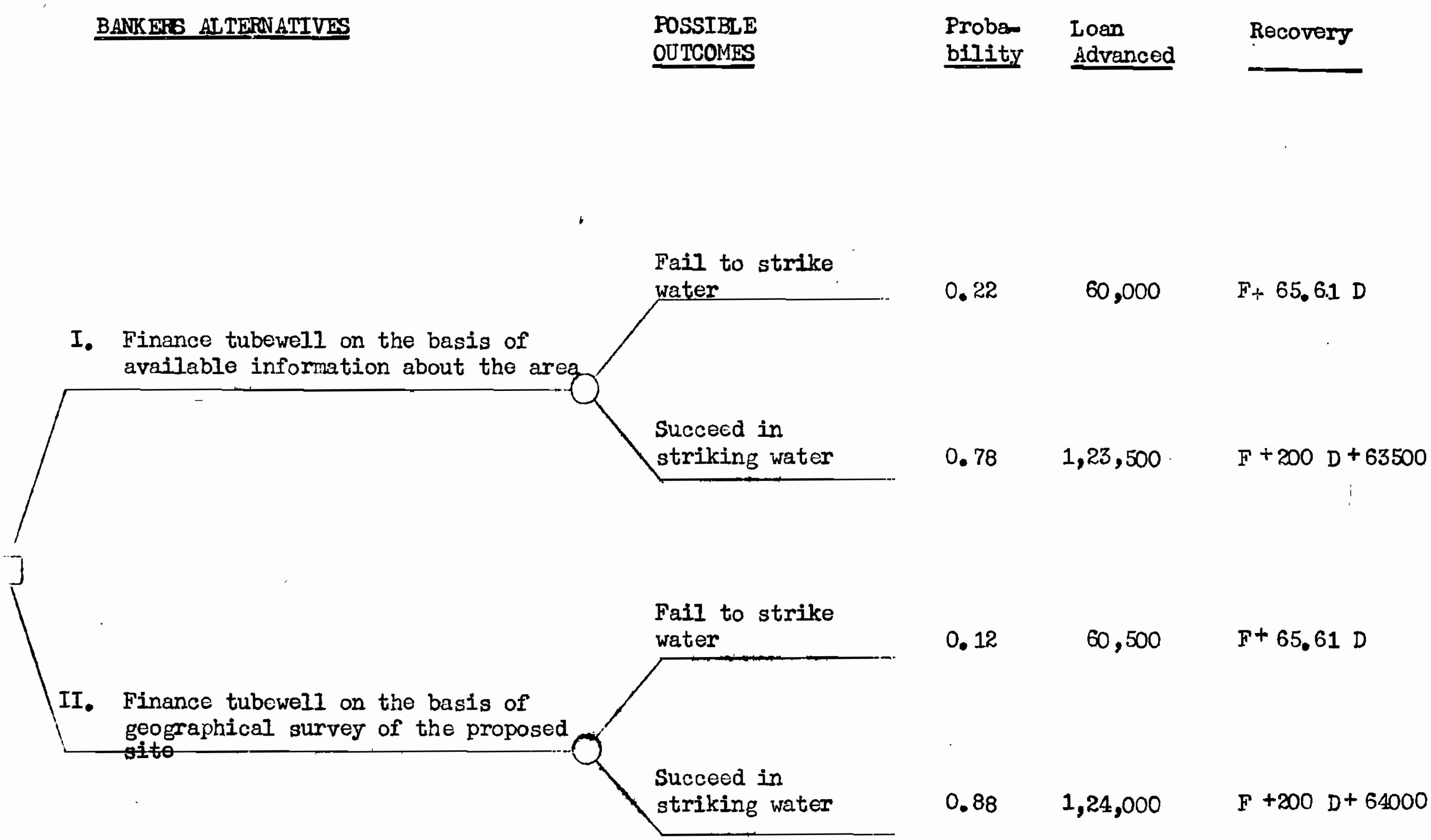

FIGURE 1: DECISION TREE DIAGRAM OF BANKER'S ALTERNATIVES IN ADVANCING FOR TUBEWELLS

In the case of alternative II, the only changes in recovery and cost are the addition of Rs. 500 as testing cost (Figure 1). The interest earnings have not been considered as they are compensation for the future repayments whose present value is less by that extent.

The expected monetary value has been used as the criterion of choice. Since bankers do not make additional profit (loan plus interest whose present value is loan amount itself), we have put the expected monetary value as zero and calculated the amount to be contributed to risk fund under each alternative. These values are presented in Table 8. The alternative II turns out to be better because total contribution to the risk fund amounts to only Rs. 4,898, per tubewell loan or 3.95 per cent of the loan. These figures would, however, vary from district to district (even from taluka to taluka) depending upon the probabilities associated with the events (success and failure) and costs of drilling. If the estimated contribution to the risk fund was to be shared by the banker and the cultivator, the amount contributed by the farmer would be reduced further.

Example 2: Decision about subsequently failed wells

In this problem, the banker has to decide about the action to be taken to minimize losses from wells which failed after successful initial installation. For illustrative purposes, two alternatives are considered: (I) auction off the failed tube well, or (II) finance further drilling of the well to make it operational again (Figure 2). In the case of alternative I there is no uncertainty. The officials of the Directorate of Ground Water Investigation, Ahmedabad indicated that if they auction off the failed tubewells, the recovery comes to about Rs. 7,000. In the case of alternative II, bankers finance 50 meters of further drilling (this alternative is open because most of the wells fail due to lowering of water table, particularly in Mehsana). In this case one of the two events might happen: Borrower may fail in striking water or may succeed in striking water. The probabilities associated with these events were again worked out with past data (Figure 2). In case the borrower fails to strike water, the banker gets only Rs. 7,000 by auctioning the well. If the borrower succeeds in striking water, the entire loan can be recovered with interest (interest is not considered for reasons given in example 1). If the expected monetary value is again used as the criterion of choice between the alternatives, the alternative which yields minimum expected loss (since expected monetary value in this case

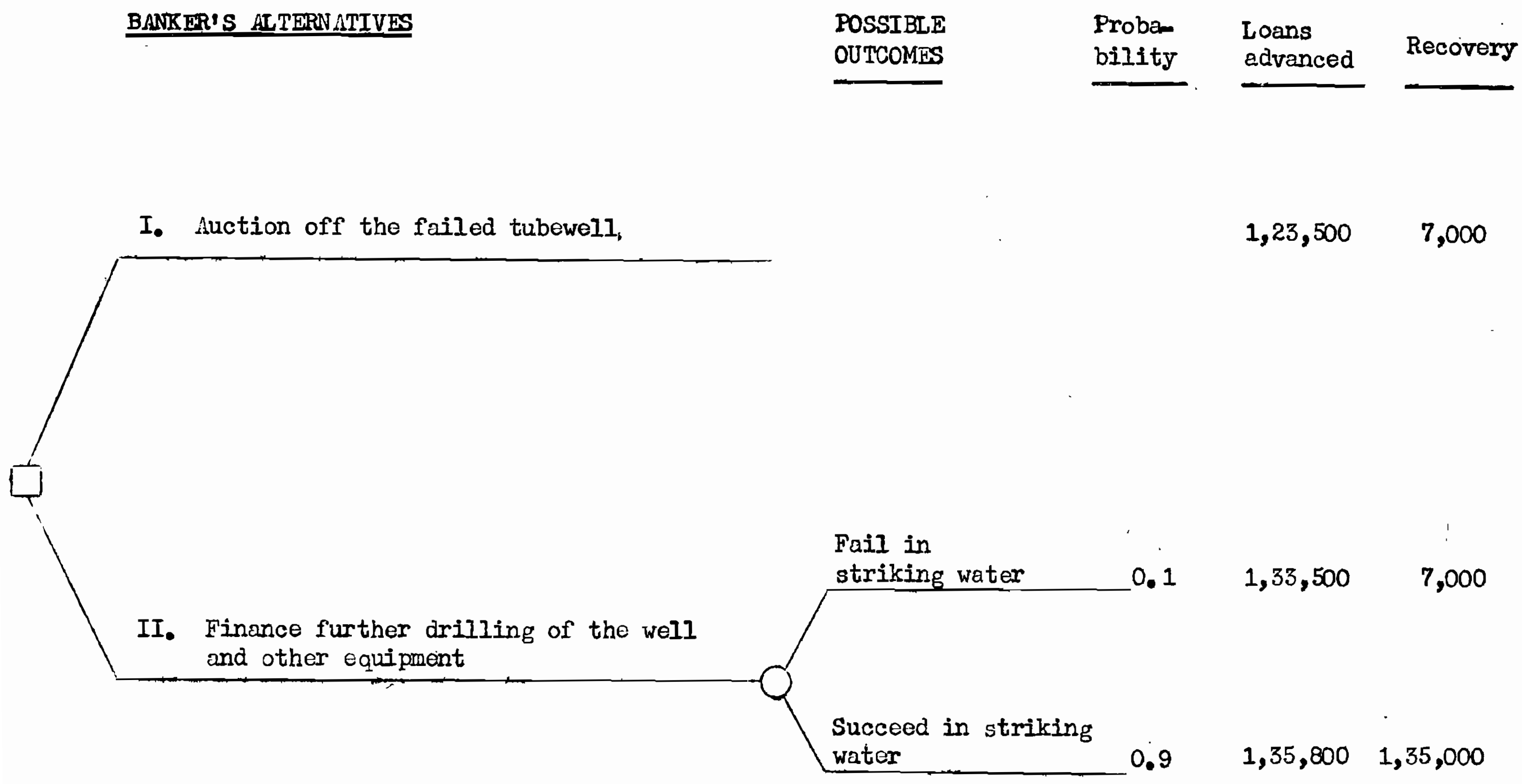

FIGURE 2: DECISION TREE DIAGRAM OF BANKER'S ALTERNATIVES IN DEALING WITH TUBEWELLS WHICH FAILED AFTER SUCCESSFUL INSTALLATION

is in terms of losses) is to be chosen. The expected losses from two alternatives are worked out in Table 9 (using the data in Figure 2). Alternative II causes an expected loss of only Rs. 12,650 as against expected loss of Rs. 1,16,500 for alternative I. The difference between the expected losses is so large that the decision would not change even if the probability associated with the event of failure to strike water was much higher in the case of alternative II.

Revision of probabilities with more data from operations

In the lending scheme was to incorporate the percentage contribution to risk fund based on example 1, as more data is gathered from operations the probabilities can be revised. It can be seen that with the revision of probabilities associated with various events in each alternative, the amount to be contributed to risk fund would also get altered. The revision of probability is affected by using Bay's theorem (3,5,7 and 8). Without giving the mathematical formula underlying the theorem, it is illustrated with the help of data on probabilities in example 1, alternative II, and additional information. Suppose that 100 loans were granted for tubewells out of which 90 succeeded. The method to use this additional information is illustrated in Table 10. The possible events in alternative II of example 1 are (i) failed to strike water or (ii) succeeded in striking water. On the basis of earlier information from Mehsana district the probabilities associated with the two events were 0.12 and 0.88 respectively for failure and success. These are referred as prior probabilities. On the basis of additional information (100 tubewells drilled and 90 succeeded) the conditional probabilities (conditional on additional information from total 100 loan and 90 of them successful) work out to be .10 and .90. The prior probability of an event multiplied by conditional probability is referred as joint probability and this forms numerator of the Bay's theorem and the sum of joint probabilities of all possible events forms the denominator of the theorem. Solving the equations, we get the revised probabilities of failure and success as 0.015 and 0.985 respectively. Since both events are mutually exclusive and collectively exhaustive, the sum total of the revised probabilities associated with both events is also unity. These revised probabilities can be used to arrive at the expected monetary value of the alternative and, hence, at a decision.

It may be stated here that several variants of the two examples cited above can be examined with more alternatives and complexities. The simple examples presented above, however, illustrate that the decision theoretic framework can provice a rational basis for estimating the contributions to risk fund and mitigating the hardships from failed wells.[2] If the framework is accepted for estimating the contributions to risk fund, we have to decide whether it should be applied at district or regional or even at national level. We should also decide whether it should be applied by each bank separately or be area based and applicable to each bank operating in that area. The broader coverage will have the advantage of keeping the farmer's contribution at manageable level in more risk prone districts.

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[2]In operational terms, similar ideas have already been tried by the State Bank of India and other banks in cattle development financing schemes. The borrowers are required to allocate 3 per cent of the amount for cattle insurance.

Table 1: Sourcewise Details of Targets of Minor Irrigation

(million hectares)

Source	Target
1. Ground Water	4.5
2. Surface Irrigation from Storage and Diversion Schemes	1.0
3. Lift Irrigation from streams or rivers	0.5
Total	6.0

Source: Government of India, Planning Commission, Draft Fifth Five Year Plan, 1974-79, p. 110.

Table 2: Development of Ground Water Resources

(in thousands)

Items	Progressive Total at the end of	
	1973-74*	1978-79**
Dug Wells	6,925	7,825
Private Tubewells	810	1,445
Public Tubewells	20	30
Electric Pumpsets	2,441	4,019
Diesel Pumpsets	1,753	2,750

*Preliminary **Target

Source: Government of India, Central Ground Water Board, New Delhi.

Table 3: Schemes Sanctioned by ARDC for Minor Irrigation during 1974-75 and 1975-76

(Rs. in lakhs)

Type	1974-75				1975-76			
	No.of Sch.san.	Financial assistance	ARDC commitment	Disbursement	No.of Sch.san	Financial assistance	ARDC commitment	Disbursement
1. Minor Irrigation	303 (48.63)	16610 (70.45)	14817 (72.40)	8378 (78.74)	410 (45.10)	18683 (52.42)	16681 (56.18)	10818 (63.20)
2. Total	623 (100)	23585 (100)	20439 (100)	10640 (100)	909 (100)	35636 (100)	29691 (100)	17115 (100)

Figures in brackets indicate percentage share to the total.
Source: Reserve Bank of India, Report on Currency and Finance, Vol. I, Economic Review, Bombay, 1976.

Table 4: Reasons for the Failure of Wells and Tubewells

Type of Failure	Reasons
1. Failure to strike water at a reasonable depth (drilling stage)	(i) Improper sitting of wells (ii) Drilling difficulties (iii) Salinity of water
2. Subsequent failure after successful installation of the well	(i) Fall in the ground water table (ii) Close spacing of wells causing hydraulic interference (iii) Deterioration in the chemical quality of water (iv) Inadequate design (v) Caving in of wells in light soils

Table 5: Cumulative Number of Tubewells Drilled in Gujarat

Year	Total no. of tubewells (cumulative)	Total no. of successful wells (cumulative)
1956	336	287
1961	726	337
1966	1048	730
1967	1149	814
1968	1258	926
1969	1256	1045
1970	1413	1117
1971	1448	1123
1972	1504	1170
1973	1600	1241
1974	1788	1364
1975	1883	1458
1976	1945	1522

Source: From the statistical records of Ground Water Resources Development Corporation, Gandhinagar.

Table 6: Tubewells Drilled in Mehsana District During Various Plans and Special Programmes

Year	Total tube-wells drilled	Total successful tubewells	Percentage of successful tubewells to total tubewells
Old Baroda State	27	27	100.00
First Five Year Plan Period	241	210	71.36
Second Five Year Plan Period	143	127	88.81
Third Five Year Plan Period	170	146	85.88
Fourth Five Year Plan Period	56	50	89.28
Fifth Five Year Plan Period	8	8	100.00
Drought Prone Area Programme	7	7	100.00
During Rabi Campaign	21	17	80.95
Total	673	592	87.96

Source: Obtained from the records of the Directorate of Ground Water Investigation, Ahmedabad.

Table 7: Installation Cost of a Tubewell in Mehsana District, Gujarat

	Details of Components	Total Cost
1.	Drilling cost (300 mts. depth)	60,000
2.	Piping cost (14" diameter pipe)*	13,800
3.	Engineering cost (electrical submersible pump etc.)	40,000
4.	Strainer pipe and other small accessories	9,700
	Total cost of one tubewell	1,23,500

*Alternatively, 8" pipe can also be used but in that cost of piping goes to Rs. 20,700

Source: Obtained from the records of the Directorate of Ground Water Investigation, Ahmedabad.

Table 8: Amount to be Contributed to Risk Fund

Alternative	Expected Monetary Value of Alternatives in Figure 1	Amount to be contributed to risk fund (F)	Amount to be contributed to risk fund (F) as a percentage of total loans
I	$[0.22 \{(F+65.61D) - 60000\} + 0.78 \{(F + 2000 + 63500) - 123500\}]$	8869.74	7.18
II	$[0.12 \{(F + 65.61D) - 605000\} + 0.88 \{(F + 2000 + 64000) - 124000\}]$	4898.04	3.95

Table 9: Expected Losses Under Each of the Alternatives

Alternatives	Expected Monetary Values (Losses) of alternatives in Figure 2	
I	1,23,500 - 7,000	= 1,16,500
II	.1(1,33,500* - 7,000) +.9(1,35,800**-1,35,800)	= 12,650

*Includes Rs. 1,23,500 of original cost plus Rs. 10,000 being the cost of subsequent drilling of 50 meters.

**In addition to the original cost of Rs. 1,23,500 and Rs. 10,000 being the cost for subsequent drilling (of 50 meters), the figure also includes Rs. 2,300 of additional expenditure as extra pipelines and accessories.

Table 10: Revision of Probabilities with Additional Data

Possible events in alternatives II excerpts 1	Prior probabilities	Conditional probabilities based on 100 tubewell drilled with 90 of them successful	Joint probability	Revised probabilities
Fail in striking water	0.12	0.10	0.012	0.015
Succeeded in striking water	0.88	0.90	0.792	0.985
			0.804	1.000

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