project planning and management series

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ACKNOWLEDGEMENT

The Project Planning and Management Series consists of a set of manuals and associated modules presenting practical approaches, tools and techniques for project planning and management. (See list on back cover). A product of the Government of Jamaica/USAID National Planning Project (1976-1980), the series was developed by the Project Development Resource Team (PDRT) of PAMCO for use in "action-training" workshops and reflects extensive experience in training and project development. All present PDRT members are contributing authors and have worked together in writing, revising and publishing the series. Special credits are due to Dr. Merlyn Kettering for design and development of the series; Dr. Bruce Brooks for writing final versions of many modules; Mrs. Marjorie Humphreys for assuming primary editing and production responsibility and for organizing draft papers into more useful materials; Mr. Lascelles Dixon, head of PDRT since 1979, for designing the cover and improving many of the illustrations; and Mrs. Christine Hinds and Miss Linette Johnson for typing the drafts and final manuscripts. Any comments on the series and its usefulness are welcome.

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MODULE 13

PROJECT TECHNOLOGY ANALYSIS

Conrad Smikle

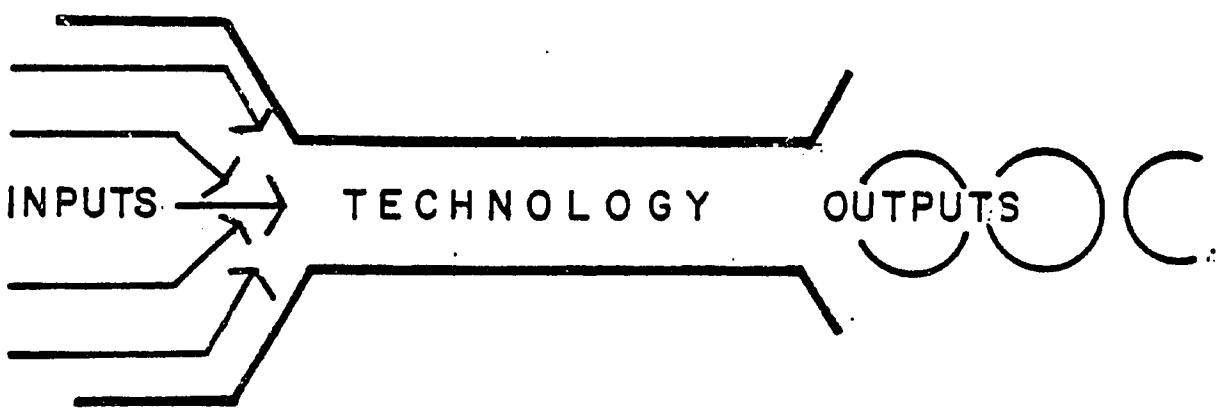
A. *PREREQUISITES:* MODULE 26 - Social Analysis

References: MODULE 25 - Internal Rate of Return
MODULE 29 - Project Selection Analysis

B. *DISCUSSION:*

Project technology refers to the means by which project inputs are converted into desired outputs. It encompasses the technical process or processes employed in the project. Diagramatically, the relationship of project technology to the other elements of the project is shown in FIGURE 13.1.

FIGURE 13.1



Review of the project technology starts with the end product and the kinds of raw material, supplies, processes and labour that can produce it. In some cases the end product can be produced by one process only, but generally there are many ways of manufacturing, processing or fabricating. Project Technology, however, refers not only to technical production processes as in manufacturing, processing or fabricating but it also refers to methods of delivery services as in health, education, social welfare.

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Whether the outputs be goods or services the project technology is essentially a production technique. The technological studies will identify the various technical alternative ways of constructing and operating the project and will then subject each of them to a detailed examination in relation to the physical, technical, economic, social and cultural factors present in the environment.

C. *PURPOSE:*

Since project technology is an indispensable link between inputs and outputs, technological studies become a critical step in project planning. The technological study will necessarily involve a detailed examination of the alternative ways of carrying out the project so that the best alternative may be selected later. (SEE MODULE 29 - PROJECT SELECTION ANALYSIS).

D. *USE:*

To assist the Project Planner in selecting the most appropriate technology for more detailed plans to be formulated for the project.

E. *DEFINITIONS:*

1) A *capital intensive technology* is a relatively sophisticated large-scale system using mechanical power. Efficiency is derived from the size of the system and from the use of capital.

2) A *labour intensive technology* uses the maximum of manual labour; equipment and methods are consistent with the skills and materials that are available locally and with the capability of the village to build the equipment and to finance and maintain it.

3) *Intermediate technology* constitutes a reduction in scale, and labour is substituted for machines. This technology uses systems and equipment which are simpler to use and easier to maintain than those selected for a capital intensive technology.

F. *LIMITATIONS:*

The selection process is usually tedious because of the interplay of a large number of factors.

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G. *ASSUMPTIONS:*

1. That the end-product has been identified for the project which best satisfies the felt need.

2. The preliminary plans stating the goals and objectives of the project have already been prepared and are available to the planners at this stage.

H. *OUTPUT:*

Analyses of several alternative technologies which will achieve the stated objective.

I. *STEPS IN MAKING A TECHNOLOGY ANALYSIS*

1. Identify technical alternatives.

2. Collect relevant socio-economic data.

3. Analyse each alternative.

STEP 1. IDENTIFY ALTERNATIVE TECHNOLOGIES

For any given investment proposal there exist alternative ways or technologies for producing the required output. For example, production of electricity can be done either by hydro or thermal means. Similarly, to have a national increase in dairy production in a given developing country, the alternative ways may include:

(a) development of indigenous dairy cows through breeding and up-grading;

(b) importation of high-yielding milk breeds from temperate countries.

Alternatives differ on the following technical and physical factors:

(i) production process;

(ii) size and location; and

(iii) timing and development,

all of which are further discussed below.

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i) *Alternative Production Process*

Consideration should be given to:

(a) differences in the nature of goods and services. In this case the quality of goods and services varies but they meet the same needs. For example, a road or a rail service between two points; the provision of dietary protein in a given city through plants or through animals;

(b) the stage at which a particular product is processed. For example, lumber products can be sold as sawn trees, undressed lumber, dressed lumber and furniture or finished building components. Similarly, corn as a source of animal feed can be sold as fodder, shelled corn or processed feed concentrate;

(c) the variations in technical process. For example, electrical heating or thermal heating; pasture-fed beef or feed-lot beef; traditional type day care centres or teaching oriented day care centres;

(d) the use of raw materials. For example, coal, gas, diesel or water may be used to run a generator. Again in the manufacture of silage for example, the alternative raw materials may be grass, corn or sorghum; and

(e) the use of factors of production, i.e., capital and labour. The use of varying degrees of capital and labour results in either:

1) a capital intensive technology;

2) a labour intensive technology; or

3) an intermediate technology;

from one location to another. Locational forces may be classified as:

(a) quantifiable; or

(b) qualitative or not easily quantifiable.

The quantifiable forces include such factors as:

i) cost of land;

ii) distance to market;

iii) freight rate;

iv) cost of raw materials;

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v) cost of buildings;

vi) cost of preparing site;

vii) taxes and legal fees;

viii) cost of utilities; and

ix) cost of labour.

The qualitative forces include such factors as:

i) condition of infrastructural development;

ii) availability and efficiency of certain utilities;

iii) type of climate;

iv) availability of commercial and community facilities;

v) qualifications of the labour force; and

vi) extent of housing development.

iii) *Timing and Development*

The phasing of the project is another important part of the technological process. Development of a project may be incremental or all at once. Incremental development involves the progressive addition of smaller units of capacity in order to meet increased growth in demand for the project's outputs. This approach involves lower initial capital costs and is more flexible and less risky than large units. On the other hand, full development in the early stages provides for future demand but may result in idle capacity in earlier years.

Idle capacity, however, may be compensated for by lower per unit costs in later years.

STEP 2 COLLECT RELEVANT SOCIO-ECONOMIC DATA

Socio-economic studies should be carried out and data collected to provide the following information:

i) availability of skilled and unskilled labour;

ii) infrastructural development;

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i) educational standards; and

iv) cultural pattern - willingness to produce specified raw materials and to use given techniques; e.g., Adventists, Rastafarians and Muslims may not be willing to produce pigs for a pork processing project; farmers might not be willing to apply fertilizers or to use a certain agricultural chemical; parents may be unwilling to send children to a certain type of school or to take them to certain types of health clinics.

STEP 3 ANALYSE EACH ALTERNATIVE

The technological studies have identified the various technical alternative ways of constructing and operating the project. The element in selecting the technology will be one of "fit".

Which of the various alternatives truly "fit" the economic, social, cultural and physical environment in which it is to be applied? It will be necessary therefore that each alternative technology be examined from the following view points.

a) *Technical View Point*

Which of the alternatives have

i) the least technical complications?

ii) the greatest chance of acceptability by participants in the project, e.g., farmers, small business operators, etc.?

iii) the greatest adaptability to the use of local resources in the country?

b) *Financial View Point*

Which alternative has

i) the lowest cost per unit of output?

ii) the lowest foreign exchange component?

iii) the most desirable cash flow?

iv) the maximum financial returns?

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c) *From the Economic Point of View*

Which alternatives have

i) the potential of obtaining quick results?

ii) the shortest capital recovery period?

iii) the highest rate of return on capital?

iv) the widest impact on the economy?

d) *From the Management Point of View*

Which alternatives have

i) the least cumbersome management of organization?

ii) the smallest demand of skilled staff compatible with efficient operation and management?

iii) the greatest chance of being accepted and supported by supporting agencies?

e) *Institutional Arrangements*

(1) technology should be compatible with land tenure system, i.e., private and freehold - life of the project can be long and assets of a more permanent nature; permanent soil conservation measures on freehold - terraces on leasehold - tenure - consider grass as contour barriers, etc.

(2) capacity and capability of support services, e.g., (i) extension

(ii) banking

(iii) distribution

f) *Private and Public Objectives*

i) the private objectives, i.e., the individuals, the firm or the farmer;

ii) the country's main development objectives.

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i) The Private Objectives

Profit is the primary objective of most private interest in the project. "Private interest" will include:

(1) individual businessmen;

(2) cooperatives;

(3) other corporations;

(4) partnerships;

(5) farmers.

The criterion generally used for profits is the return to capital expressed as the Financial Internal Rate of Return. (SEE MODULE 25 - INTERNAL RATE OF RETURN). The objective of the farmer, however, will be one of income and the criterion used is Net Farm Family Income.

ii) The Country's main development Objectives

Some of the social and economic objectives against which alternatives must be compared include:

(1) economic growth - measured in terms of Economic Internal Rate of Return,(SEE MODULE 25 - INTERNAL RATE OF RETURN);

(2) foreign exchange earned or saved (BRUNO RATIO);

(3) employment - measured in terms of the number of jobs created per million dollar investment; and

(4) income distribution - measured in terms of the number of new families sharing in the returns from the project.

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PROJECT TECHNOLOGY ANALYSIS

EXERCISE 13.1

Problem Set:

Using the information and data provided below, identify the technology which satisfies the criterion of least cost.

The selection of alternative technology is quite often based on a least cost approach. That is, for a given project, the technology which permits the lowest project cost is chosen from among the possible alternatives. Where the alternatives are many, the selection exercises based on least cost will involve Linear Programming technique. However, for relatively few alternatives, e.g., three or four, a simple graphical analysis will suffice.

The following example will serve to illustrate the selection process using simple graphical technique.

PROJECT: *ELIM RICE PROJECT*

This project entails production of rice in the Black River Upper Morass Valley - Jamaica. Three possible alternative technologies are contemplated.

Alternative A:

This alternative will be labour intensive. Land Preparation employs a maximum of manual labour but will be assisted by mule-drawn ploughs. Harvesting will also be done by manual labour and threshing by machines.

Alternative B:

This will be an intermediate technology using small tractors (15 h.p.) for land preparation. Harvesting will be done by the use of sickles and threshing by machines.

Alternative C:

This will be a capital intensive technology and assumes that land preparation will be done by big machinery (50 h.p.) and harvesting by combine harvesters.

The demand for the project's output of rice is estimated at three million pounds in the first year of operation. However, demand is forecast to be growing at a rate of approximately 6% per year, reaching approximately nine million pounds in 20 years. One of the objectives of the project is to meet this demand over the period.

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The variable costs of production for each technology are broken down as follows:

Cents per Unit

TECHNOLOGY	RAW MATERIAL	LABOUR	ENERGY	TOTAL
A	6.30	3.50	0.20	10.00
B	5.50	1.50	0.50	7.50
C	4.50	0.50	1.00	6.00

The costs of production as well as the maximum production capacities for each alternative are shown below:

TECHNOLOGIES	INVESTMENT COST	FIXED COST	VARIABLE COST	MAXIMUM PRODUCTION CAPACITIES LBS.
A	$ 240,000	$ 50,000	10¢ per unit	3 million lbs.
B	900,000	150,000	7.5¢ per unit	5 million lbs.
C	1,500,000	300,000	6¢ per unit	12 million lbs.

Earlier PDRT working papers relevant to this topic include "Technical Analysis", D. Logan, 1977. (8 pages), and "Technological Factors in Project Development, M. Kettering and J. Kristiansen, 1977. (17 pages).

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APPENDIX 13.1

PROJECT TECHNOLOGY ANALYSIS

SOLUTION TO EXERCISE 13.1

1. Figure 1 is a graphical representation of the data provided for the three alternatives viz. A, B, and C. Selection is based on *the least cost* approach. (SEE p. 13.1.2).

2. *ANALYSIS*

   Technology A: Shows lowest cost for the production of the first three million pounds of rice. Between 3 and 5 million pounds, cost is lower than C but higher than B. Between 5 and 6 million pounds, A is lower than B but higher than C.

   Technology B: Shows lowest cost between 3 and 5 million pounds of rice. Between 6 and 9 million pounds, B is lower than A, but higher than C. B shows lowest cost for only 2 million pounds.

   Technology C: Shows highest costs for the first 5 million pounds of rice but shows lowest costs between 5 and 9 million pounds.

3. *CONCLUSION*

   Technology C is identified as satisfying the criterion of least cost, since it shows the lowest cost for the longest period of time.

   NOTE: It is emphasized that, for the purpose of this exercise, selection is based only on the cost factor. No consideration is given here to other factors (or criteria for selection) which need to be considered before making a final decision on the most appropriate technology.

   This exercise must be seen as an illustration of the principle of analysis using the method of least cost analysis

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FIGURE 1: GRAPH SHOWING PRODUCTION COSTS USING ALTERNATIVES A, B, C.

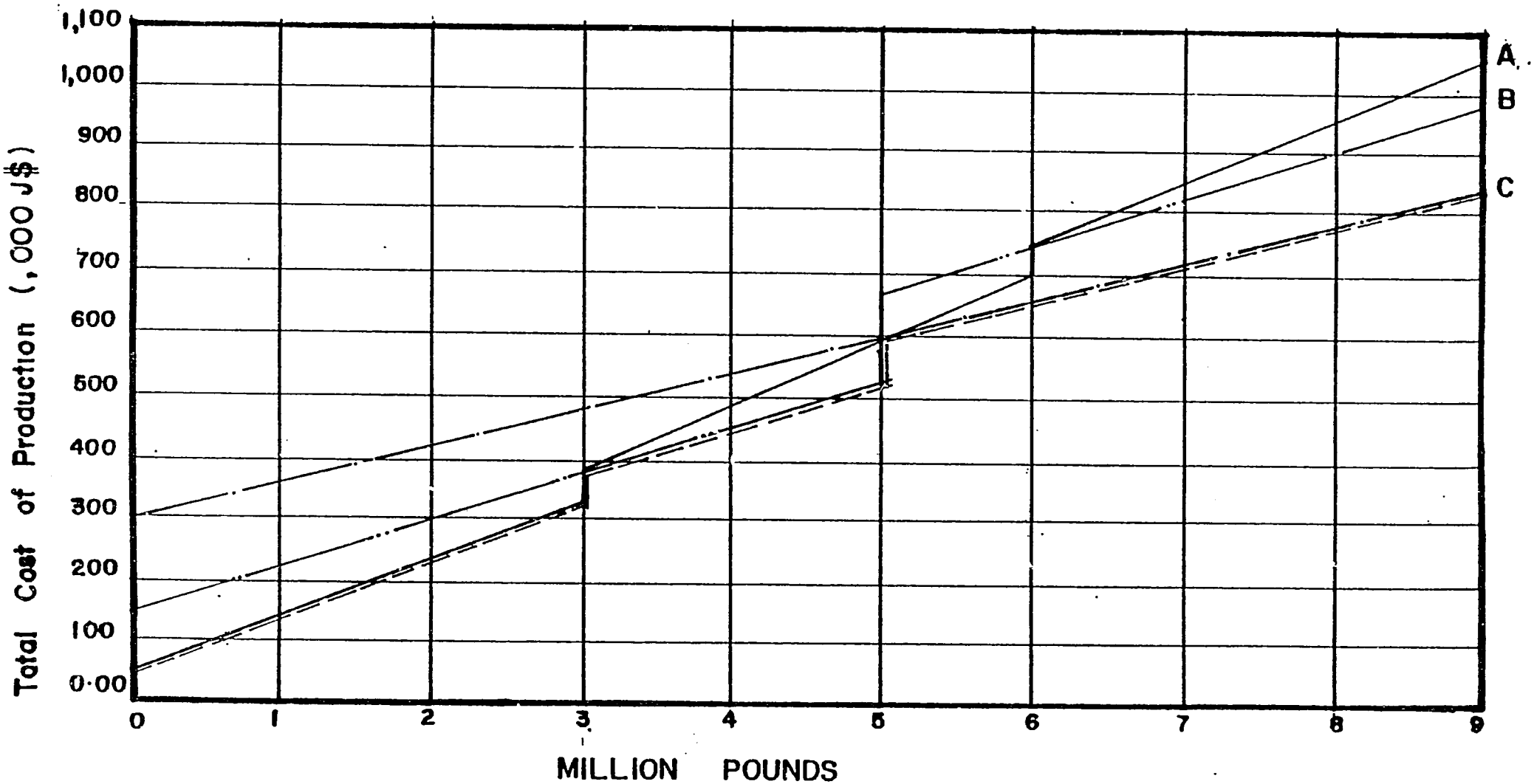

Figure 1

COST OF PRODUCTION USING ALTERNATIVES A, B & C

Alternative A ——
Alternative B —·—
Alternative C —·—

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APPENDIX 13.2

EXERCISE 13.2

LOCATION ANALYSIS EXERCISE

TOMATO PROCESSING PLANT

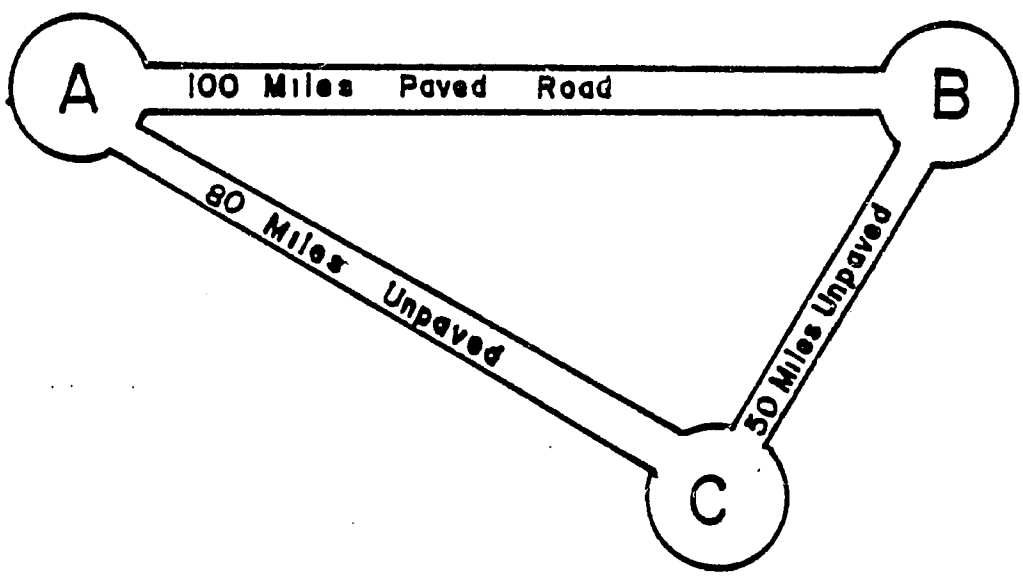
Problem Set

Based on a least cost, analysis recommend the town in which the plant is to be sited.

Three possible towns are identified for locating a tomato processing plant in Jamaica. For convenience these towns are named Town A, B and C.

Town A is 100 miles from Town B and they are linked by asphalted roads. Town B is 50 miles from Town C and they are linked by unpaved roads. Town C is 80 miles from Town A and they are also linked by asphalted roads. Figure 2 shows the relative locations of these towns.

FIGURE 2



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The cost of transportation on unpaved roads is 50c/ton/mile and on paved roads 20c/ton/mile.

Rate of spoilage of fresh tomato from C to A is 5%. Rate of spoilage from C to B is 20%. Note that Town C lies in the major producing areas of tomatoes while the total supplies for Town A and B will have to come from the areas surrounding Town C.

The total demand for the tomato paste is 6,000 tons for the first year of operation of the plant but is projected to be increasing by 10% per year for the next five years.

The present demand (6,000 tons) is estimated for Towns A, B, and C as follows:

Town	Demand (tomato paste) (tons)
A	2,000
B	3,500
C	500

Cost of fresh tomato is $20/ton. Conversion ratio of fresh tomato to tomato paste is 1:0.5 or 50%.

Preliminary investigations reveal that lack of infrastructure and utilities in Town C prohibits the siting of the plant at that location.

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APPENDIX 13.2
PROJECT TECHNOLOGY ANALYSIS

SOLUTION TO EXERCISE 13.2
LOCATION ANALYSIS

TOMATO PROCESSING PLANT

Town A

Quantity tomato paste to be produced	=	6000 tons
Conversion ratio fresh tomato to paste	=	1:0.5
∴ Quantity required	=	12000 tons
But loss intransit C - A	=	5%
∴ Quantity required	=	$\frac{12000}{95} \times 100$
	=	12,631 tons
Cost per ton	=	$20
∴ Cost of raw material	=	12631 x 20
	=	$252,620
Cost of transportation (fresh tomato) C - A	=	20¢/ton/mile
∴ Total cost of transportation	=	12,631 x .2 x 80
	=	$202,096
Cost of transportation tomato paste A - B	=	3500 x .2 x 100
	=	$70,000
Cost of transportation tomato paste A - C	=	500 x .2 x 80
	=	8,000

∴ Total cost of siting plant at Town A:

Raw material	=	$252,620
Transportation	=	202,096

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Transportation	=	70,000
"	=	8,000
Total		$532,716

Town B

Quantity tomato paste to be produced	=	6000 tons
Conversion ratio tomato/paste	=	1:0.5
∴ Quantity required	=	12,000 tons
But loss intransit C - B	=	20%
∴ Quantity required	=	$\frac{12000}{80} \times 100$
	=	15,000 tons
Cost per ton	=	$20
∴ Total cost raw material	=	15000 x 20
	=	$300,000
Cost of transportation (fresh tomato) C - B	=	50¢/ton/mile
∴ Total cost of transportation	=	15,000 x .5 x 50
	=	$375,000
Cost of transportation tomato paste B - A	=	
		2000 x .2 x 100
	=	$40,000
Cost of transportation (paste) B - C	=	
		500 x .5 x 50
	=	12,500

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Total cost of siting at Town B:

Raw material	=	$300,000
Transportation	=	375,000
"	=	40,000
"	=	12,500
Total		$727,500

CONCLUSION: The analysis shows that it will cost less to site the plant at A therefore, A will be the recommended location.

NOTE: It is emphasized that, for the purpose of this exercise, selection is based only on the cost factor. No consideration is given here to other factors (or criteria for selection) which need to be considered before making a final decision on the most appropriate technology.

This exercise must be seen as an illustration of the principle of analysis using the method of least cost analysis.

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MANUAL - I Planning for Project Implementation
MANUAL - P Project Planning
MANUAL - M Project Management
MANUAL - PF Pioneer Farm Implementation Planning

MODULES

1. Defining Project Objectives (Objective Trees)
2. The Logical Framework
3. Work Breakdown Structure
4. Activity Description Sheets
5. Project Organization
6. Linear Responsibility Charts
7. Project Scheduling - Bar Charts
8. Bar Charting for Project Control/Scheduling
9. Project Scheduling - Network Analysis
10. Milestones Description Charts
11. Resource Planning & Budgeting
12. The Role of PAMCO
13. Project Technology Analysis
14. Demand Analysis
15. Market Strategy Analysis
16. Project Area Analysis
17. Project Costs & Benefits
18. Project Profile
19. Financial Analysis
20. Cash Flow Analysis
21. Discounting
22. Net Present Worth Analysis
23. Cost-Benefit Analysis
24. Benefit-Cost Ratio Analysis
25. Internal Rate of Return
26. Social Analysis of a Project
27. Economic Analysis of Projects (including Border Pricing)
28. Financial Statements & Ratios
29. Project Selection & Ratios Analysis
30. Brainstorming
31. Decision-making System for Projects
32. Project Institutional Environmental Analysis
33. Ecological Analysis for Projects
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