Inter-American Institute of Agricultural Sciences
Office in the Dominican Republic

A METHODOLOGICAL APPROACH TO IDENTIFYING AND REDUCING POSTHARVEST FOOD LOSSES

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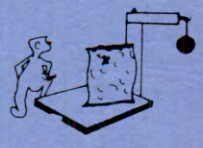

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PREFACE

In recent decades, available resources for developing the agricultural sectors of lesser developed economies have been concentrated in projects designed to stimulate production and productivity. This strategy has produced the following positive results:

- An increase in total grain yield per hectare of the order of 42% (36).
- An increase of approximately 78% in total grain production (36).
- A total rate of growth of production very similar to that of the more developed countries (28).

Thus according to some world statistics (36), we are now very close to producing the total quantity of food theoretically necessary to supply minimum nutritional needs. Nevertheless, in Caribbean and Latin American Countries alone more than 36 million people suffer from HUNGER and/or a critical state of malnutrition (28).

The preoccupation with the high level of post harvest food losses on a worldwide basis culminated in September of 1975 in a resolution from the Seventh Special Session of the United Nations General Assembly assigning priority to the reduction of post-harvest food losses by 50 percent by 1985. Since that resolution, attention has been concentrated on the preparation of a manual for estimating post-harvest grain losses (77) and the identification and implementation of infrastructure projects (e.g. silos) to reduce these losses.

With the exception of selected trials and experiments with a few products, in a few countries, very little has been done in the quantification and reduction of post-harvest losses of perishable produce such as fruits, vegetables and root crops. This document is an attempt to help fill this vacuum, by offering a methodology towards this end, using a systems approach and with and orientation towards the identification of specific projects to reduce losses.

It was originally presented in Spanish at the Seminar on Reduction of Post Harvest Food Losses in the Caribbean and Central America sponsored by IICA and held in Santo Domingo, Dominican Republic during the period August 8-11, 1977. The principal author is Dr. Rafael Amezquita, a specialist in food Technology with many years of experience in his home country of Colombia, as well as the Dominican Republic, Mexico, Jamaica and other Central and South American Countries.

The original version of this document was considered an important first step in the preparation of a technical manual for investigating and quantifying post-harvest food losses of perishable produce. It was prepared with the hope of stimulating investigation in this important area, in countries in and around the Caribbean, and has in fact done so in the Dominican Republic, Guyana and Mexico.

Dr. Amezquita and colleagues were working on a more complete revised version when he died suddenly in May 1978 in Mexico City, Mexico.

Due to the considerable interest in the reduction of post-harvest losses of perishable produce in the English speaking Caribbean, and the scarcity of publications analyzing the problem from a systems point of view, IICA decided to edit this document and translate it into English. The translation and publication were made possible by a grant received from the Commonwealth Secretariat.

It is hoped that this booklet will serve as a stimulus to those countries in and around the Caribbean to take a closer look at their post harvest food losses and develop systematic programs for quantifying losses and reducing them where practicable. Nothing would have pleased Rafael Amezquita more.

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A METHODOLOGICAL APPROACH TO INDENTIFYING AND REDUCING POST HARVEST FOOD LOSSES

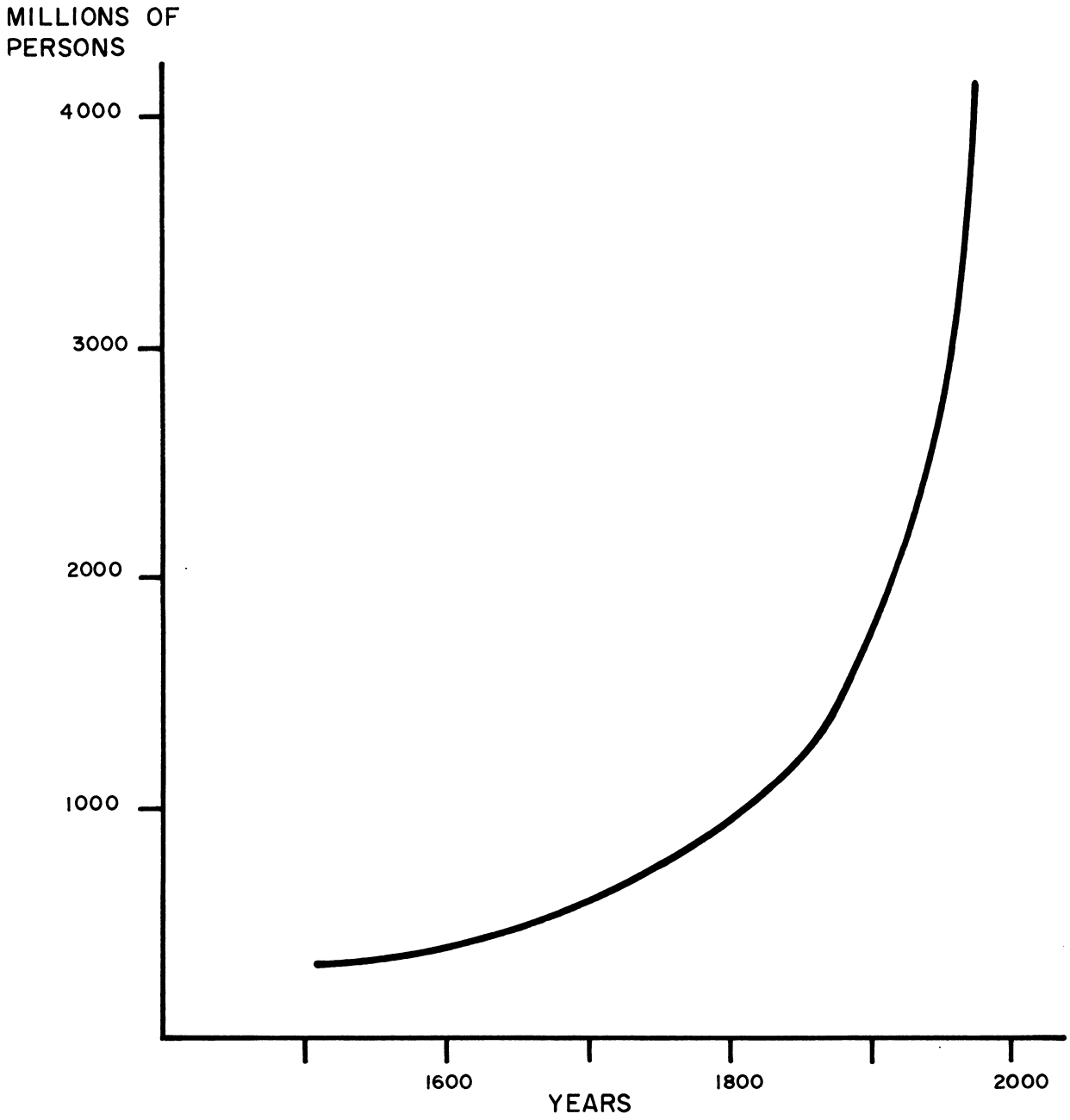
I. INTRODUCTION

Since the world was created, food supply has been one of the main worries of the human being. During all this time a continuous learning process has taken place with regard to the production, conservation and utilization of foods and many remarkable advances have been attained. Mankind, however, has not yet been able to overcome the necessary barriers to provide an adequate food supply to the citizens of the world. (28, 36).

In our time, and especially in recent decades, the world food situation, has gone through several stages: from the pessimism of the years 1965/66 we moved through the green revolution optimism (1967-70) only to return to a period of skepticism (1974 - present).

Figures 1, 2 and 3 and Tables 1 and 2 give ample testimony to the seriousness of the existing situation. As can be noted, it took 50 years for world population to grow from 2,000 to 4,000 million (1925 to 1975). The present projections, however, indicate that the next duplication shall occur in the following 25 years (1975 to 2000). The worlds annual population growth rate is actually 1.97 percent (1977) and is tending to increase. In the underdeveloped countries, which account for the majority of the present world population (2.8 billion persons), the average growth is 2.4 percent per year.

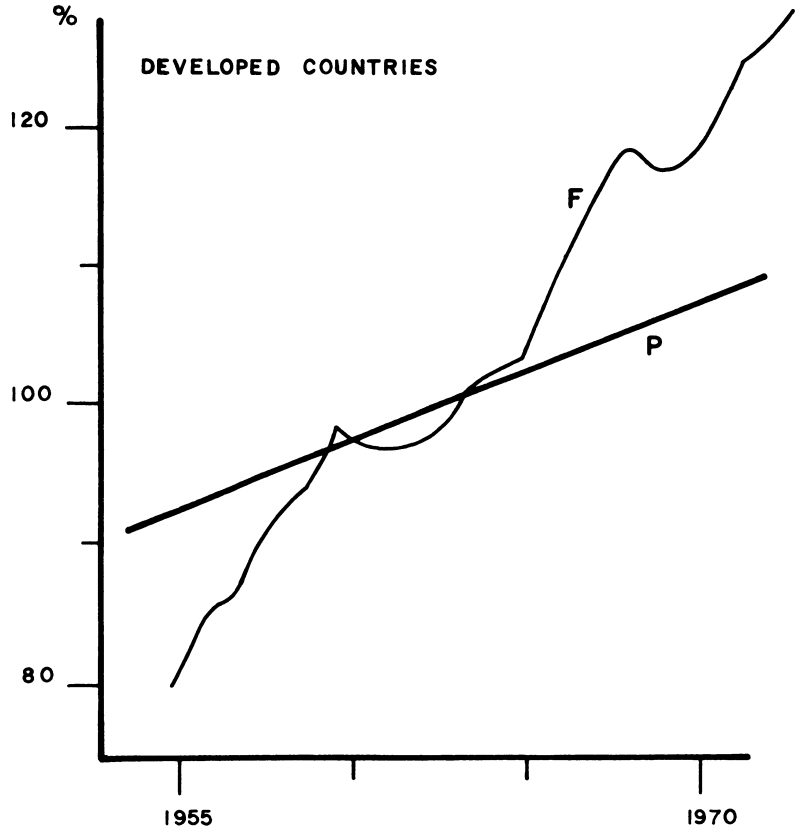
FIGURE I : WORLDWIDE POPULATION INCREASE



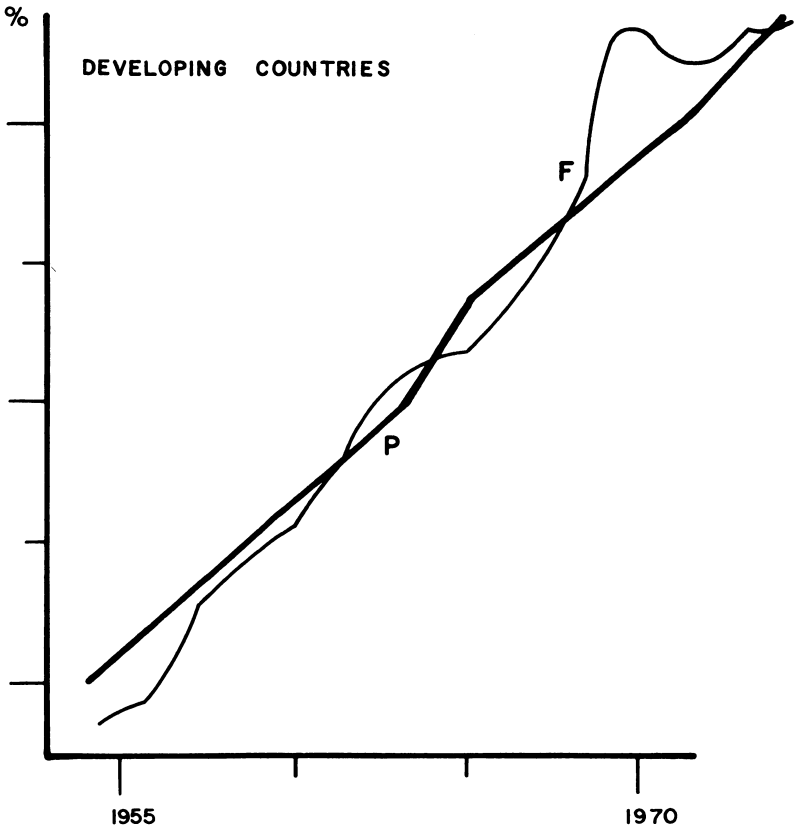
Source : TECH. FORECASTING; MEYER, 1975

FIGURE 2: INCREASE IN FOOD PRODUCTION AND POPULATION

(% OF 1961-1965)



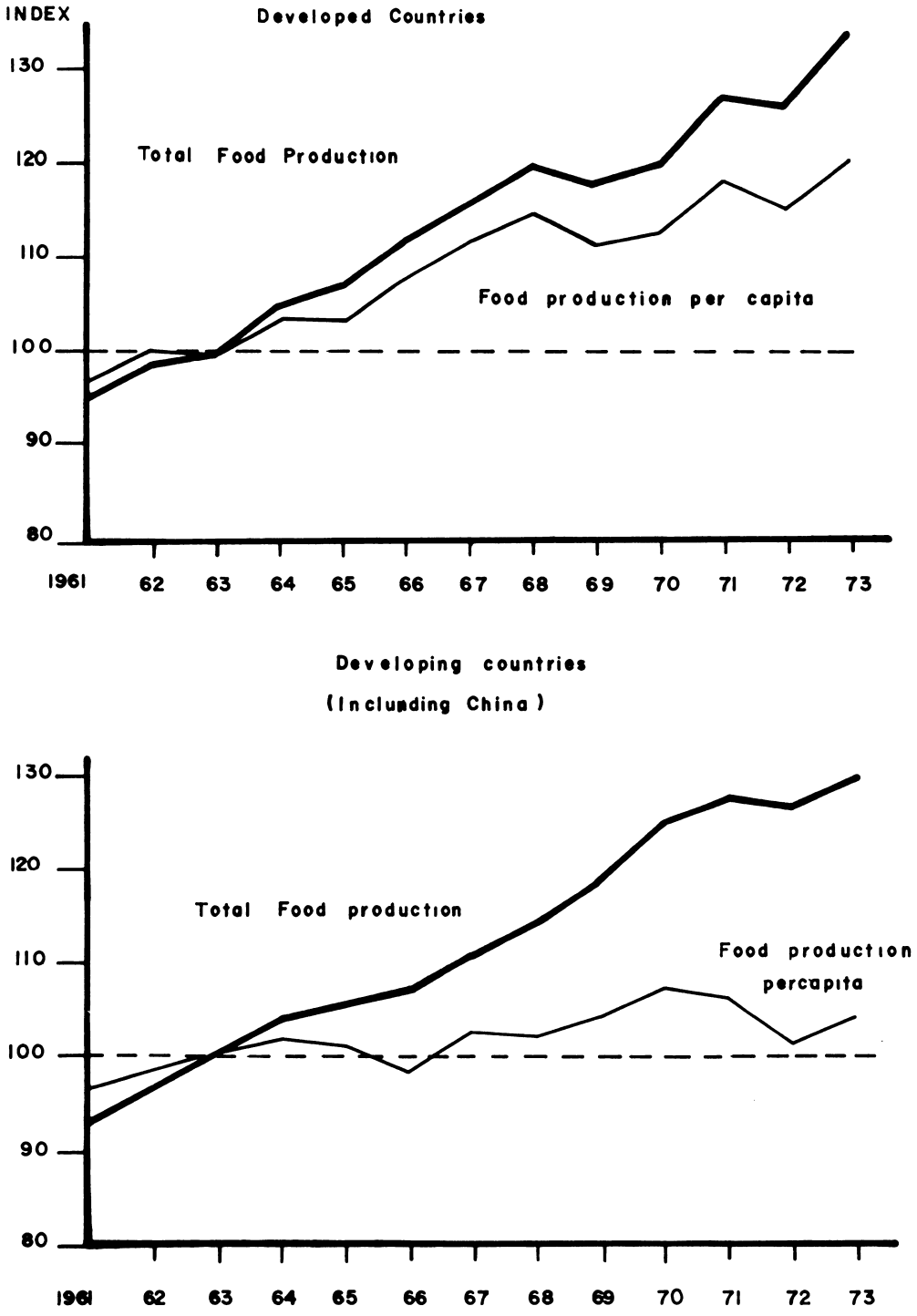
F: FOOD PRODUCTION P: POPULATION



F: FOOD PRODUCTION P: POPULATIO

SOURCE: FAO, USDA (28, 32)

FIGURE 3: FOOD PRODUCTION



Sources : FAO 1974 (28)

TABLE 1: VARIATION IN THE ANNUAL RATE OF INCREASE OF THE WORLD POPULATION.

YEAR	Population in millions	Annual Rate of Increase
2000	7692	2.63
1976	4000	1.97
1975	3922	0.42
1600	470	0.044
-2400	30	0.022
-7000	10	

Source: Based on MEYER, F. y J. VALLE, TECHNOLOGICAL STUDIES, 7,285 (1975).

TABLE 2. PERCENTAGE OF INCREASE IN FOOD PRODUCTION IN RELATION TO THE WORLD POPULATION AND ITS PRINCIPAL REGIONS 1952-62 AND 1962-72.

GEOGRAPHICAL REGIONS	1952 - 62			1962 - 72		
	Demographic Increase	Food Production		Demographic Increase	Food Production	
		Total	Per Capita		Total	Per Capita
	Annual Percentage Increase*					
Developed Market Economies**	1.2	2.5	1.3	1.0	2.4	1.4
Western Europe	0.8	2.9	2.1	0.8	2.2	1.4
North America	1.8	1.9	0.1	1.2	2.4	1.2
Oceania	2.2	3.1	0.9	2.0	2.7	0.7
Eastern Europe and U.R.S.S.	1.5	4.5	3.0	1.0	3.5	2.5
Total Developed Countries	1.3	3.1	1.8	1.0	2.7	1.7
Market Economies in Process of Development**	2.4	3.1	0.7	2.5	2.7	0.2
Africa	2.2	2.2	- -	2.5	2.7	0.2
Far East	2.3	3.1	0.8	2.5	2.7	0.2
Latin America	2.8	3.2	0.4	2.9	3.1	0.2
Middle East	2.6	3.4	0.8	2.3	3.0	0.2
Asian Countries with Centralized Planning	1.8	3.2	1.4	1.9	2.6	0.7
Total of Developing Countries	2.4	3.1	0.7	2.4	2.7	0.3
Total World	2.0	3.1	1.1	1.9	2.7	0.8

*Percentage of growth trends compounded annually.
**Includes countries from non-specified regions.

SOURCE: FAO. 1974. The Present State of World Agriculture and Nutrition.

These 2.8 billion persons produce only 40 percent of the total world food supply.

Although the production of the total food supply increased almost at the same proportion in the underdeveloped countries as in the developed countries (Figures 2 and 3), the per capita production in the underdeveloped countries only barely maintained itself in proportion with the growth of population.

Notwithstanding that the 1974 world population disposed of 20 percent more food per capita than the 1954 population, in 34 of the underdeveloped countries, that is almost 40 percent of the total, the food production could not keep up with the population growth during the same period. In the 1962-72 period the food production per capita in Latin America increased at an average annual rate of 0.2 percent.

Due to the great progress obtained in food production in many developed and developing countries, the malnurished proportion of their population has decreased considerably. However, in the third world as a whole, and according to United Nations data (28), the absolute number of hungry persons has increased.

Table 3 shows the daily dietetic rations recommended in accordance with age, type and activity of persons while Table 4 shows the nutrition energetic value and the daily protein supply in Latin American countries. Even though Latin America in general does not offer a pessimistic panorama, there are enough isolated cases of countries where the situation is near critical and tremendous efforts will be required in order to induce recovery. According to the information available in some countries (Tables 5 and 6) and as logic would dictate, the population groups with the lowest income consume smaller

TABLE 3. RECOMMENDED DAILY DIET RATION BY SEX AND ACTIVITY

Sex Group and Activity	Calories	Protein g.	Calcium g.	Iron mg.	Vitamin A. U.I.	Thiamine mg.	Riboflavin. mg.	Niacin (Cationic Acid N) mg.	Ascorbic Acid mg.	Vitamin D U.I.
MEN (154 lb. 70 Kg)										
Sedentary	2400	70	1.0	12	5000	1.2	1.8	12	75	...
Physically active	3000	70	1.0	12	5000	1.5	1.8	15	75	...
Heavy Work	4500	70	1.0	12	5000	1.8	1.8	18	75	...
WOMEN (123 lb. 56 kg)										
Sedentary	2000	60	1.0	12	5000	1.0	1.5	10	70	...
Partially active	2400	60	1.0	12	5000	1.2	1.5	12	70	...
Very active	3000	60	1.0	12	5000	1.5	1.5	15	70	...
Pre-natal period (2nd half)	2400	85	1.5	15	6000	1.5	2.5	15	100	400
Nursing	3000	100	2.0	15	8000	1.5	3.0	15	150	400
CHILDREN UP TO 12 YEARS										
Less than one year	2	3	1.0	6	1500	0.4	0.6	4	30	400
1-3 years (27 lbs. 12 Kg)	1200	40	1.0	7	2000	0.6	0.9	6	35	400
4-6 years (42 lbs. 19 Kg)	1600	50	1.0	8	2500	0.8	1.2	8	50	400
7-9 years (58 lbs. 26 Kg)	200	60	1.0	10	3500	1.0	1.5	10	60	400
10-12 years (78 lbs. 35 Kg)	2500	70	1.2	12	4500	1.2	1.8	12	75	400
CHILDREN OVER 12 YEARS										
Girls 13-15 years (108 lb. 49 Kg)	2600	80	1.3	15	5000	1.3	2.0	13	80	400
Girls 16-20 years (122 lb. 55 Kg)	2400	75	1.0	15	5000	1.2	1.8	12	80	400
Boys 13-15 years (108 lb. 49 Kg)	3200	85	1.4	15	5000	1.5	2.0	15	90	400
Boys 16-20 years (141 lb. 64 Kg)	3800	100	1.4	15	6000	1.7	2.5	17	100	400

SOURCE: N.W. Desrosier. The Technology of Food Preservation. The AVI Publishing Co., INC. Westport. Conn. U.S.A.

TABLE 4. AVERAGE AVAILABILITY OF ENERGY AND PROTEIN BY REGION.

GEOGRAPHICAL REGIONS	Energy		Protein		Energy in Percentage of Needs	
	1961	Average 1969-71	1961	Average 1969-71	1961	Average 1960-71
	Kilo-Calories per capita		Grams per capita		Percentage of needs	
Developed Market Economies	2950	3090	87.5	95.1	115	121
Western Europe	3020	3130	9.3	93.7	118	123
North America	3110	3320	92.3	105.2	118	126
Oceania	3210	3260	92.7	108.1	121	123
Other Developed Market Economies	2420	2550	73.3	79.1	102	108
Eastern Europe and U.R.S.S.	2990	3260	85.8	99.3	116	127
Total Developed Countries	2960	3150	87.0	96.4	116	123
Market Economies in process of Development	2130	2210	55.0	56.0	93	97
Africa	2120	2190	55.7	58.4	91	94
Far East	2050	2080	51.3	50.7	92	94
Latin America	2410	2530	63.7	65.0	100	105
Middle East	2200	2500	62.3	69.3	89	102
Asian Countries with Centralized Planning	2020	2170	54.7	60.4	86	92
Total Developing Countries	2100	2200	54.9	57.4	91	95
Total World	2380	2480	65.2	69.0	100	104

SOURCE: FAO. 1974. The Present State of World Agriculture and Nutrition.

TABLE 5 : ENERGY AND PROTEIN IN-TAKE OF STUDENTS AT HYDERABAD.

Age Groups	Calories		Proteins	
	Low Incomes	High Incomes	Low Incomes	High Incomes
7 - 8	1429	2186	37.0	67.8
9 - 10	1411	2343	36.5	62.1
11 - 12	1292	2833	34.5	72.2
13 - 14	1374	2585	35.5	75.5
All Groups	1376	2485	35.9	69.4

Source : DIET ATLAS OF INDIA, NACIONAL INSTITUTE OF NUTRITION, ICMR, INDIA.

TABLE 6, DAILY PER CAPITA ENERGY IN-TAKE BY INCOME GROUPS IN BRAZIL, 1960

INCOME (CRUZEIROS/YEAR PER CAPITA)	Northeast				East				South			
	Urban Areas		Rural Areas		Urban Areas		Rural Areas		Urban Areas		Rural Areas	
	Percentage of Families	K cal Per Capita daily	Percentage of Families	K cal Per Capita daily	Percentage of Families	K cal Per Capita daily	Percentage of Families	K cal Per Capita daily	Percentage of Families	K cal Per Capita daily	Percentage of Families	K cal Per Capita daily
Less than 100	9	1240	18	1500	5	1180	7	1420	1	1480	4	2380
100 - 149	13	1500	14	1810	5	1530	10	2100	3	1740	4	2900
150 - 249	26	2000	25	2140	17	1880	20	2210	11	1970	16	2500
250 - 349	17	2320	13	1820	14	2090	15	2720	13	2050	15	1860
350 - 499	14	2420	10	2280	17	2220	13	2670	20	2360	18	2970
500 - 799	11	2860	11	2370	20	2630	13	2920	22	2470	21	3000
800 -1199	5	3310	5	3380	11	2820	8	3060	14	2780	9	3780
1200 -2499	4	4040	3	2870	9	3270	11	3040	12	3080	10	4160
More than 2500	1	4290	1	2900	2	3750	3	4100	4	3170	3	4770

SOURCE: The Consumption of Food in Brazil: Study of Family Budgets in the Early 1960's, Fundación Getulio Vargas. Brazil 1970.

amounts of food and consequently have the lowest levels of caloric and proteinic intake.

The situation turns even more dramatic when we consider that, when there is insufficient food for the whole family, the working adult consumes the greatest volume of available foods, as the inactivity of a child is not as serious as an inactive adult for the survival of the family. This is especially serious for children and pregnant women who have greater nutritional needs.

The retardation in child development brought on by malnutrition is often not related by the parents to nutritional deficiencies, even though the limited physical evolution and the animic condition of the adults themselves is in a great measure a living demonstration of the hunger they suffered when they were children.

The causes of malnutrition are many and very complex. In rural areas; land, water, capital, technical know-how, access to information, credit, and other farm inputs are distributed in an unequally manner. The production patterns oriented to satisfy demands of international markets, or national groups with sufficient purchasing capacity, do not always favor diversification nor the total use of available resources. The inability to guarantee proper distribution of basic food products increases the many difficulties which aflict the small farmer and which contribute to perpetuate his poverty situation and therefore his state of malnutrition.

Table 7 indicates the approximate number and percentage of persons in the world who actually have a deficient protein and calory intake. In Latin America some 13 percent fall into this category -- equivalent to approximately 36 million persons.

TABLE 7: ESTIMATED NUMBER AND PERCENTAGE OF PERSONS WITH PROTEIN AND CALORY IN-TAKE BELOW LOWER LIMIT.

	Population	Percentage with calory intake below the lower limit	Number of people below the lower limit
	Billions	Percentage	Millions
Developed Countries	1.07	3	28
Developing Countries *	1.75	25	434
Latin America	0.28	13	36
Far East	1.02	30	301
Middle East	0.17	18	30
Africa	0.28	25	67
Total	2.83	16	462

* Excluding Asian countries with centrally planned economies.

SOURCE: FAO. 1974. Present state of World Agriculture and Nutrition.

With respect to the demand for food in the developing countries, it can be observed (Table 8) that for the next 15 years an annual increase is foreseen which will vary from 2.4 percent for sugar to 6.1 percent for poultry. For Latin America, data indicate an expected increase rate of food demand over the next 15 years on the order to 3.6 percent per year, while the expected annual increase in agricultural production for that same period is projected at 2.9 percent.

These data lead us to consider another aspect of the world food situation, which if the necessary measures are taken, may help considerably to close the breach between the real demand for food and available supply. That to which we are referring is: THE REDUCTION OF POST HARVEST FOOD LOSSES.

World-wide statistics vary considerably in the estimation of food losses. This is due, in part, for the lack of a standard methodology accepted by researchers on the subject matter. Nevertheless, if we look at preliminary estimates presented in Table 9, the figures are substantial, in most cases exceeding 15 percent of production and sometimes reaching as high as 80 percent. The causes are also variable, with insects, fungi, rodents, climate and improper handling practices being the most common.

In 1948, Cotton estimated, based on a survey carried out in 27 countries, that some 65 million metric tons of food, sufficient to provide caloric needs for more than 100 million persons (26), were lost annually.

In 1975, Pimentel and other researchers estimated that total world post-harvest food losses where on the order of 20 percent and that in the lesser developed economies these losses reached as high as 48 percent. FAO, at the same time, estimated that in general, and due to diverse causes, between 20

TABLE 8. TOTAL DEMAND OF DEVELOPING MARKET ECONOMIES FOR SOME PRINCIPAL PRODUCTS BY GROUPS /1.

PRODUCTS	CONSUMPTION	PROJECTED DEMAND			TOTAL INCREASE		COMPOUNDED GROWTH RATE	
	1969-71	1980	1985	1990	1970-85	1970-90	1970-85	1970-90
	Million M/tons				Percentage		Anual Percentage	
Cereals /2	385.70	534.3	628.5	737.6	63.0	91.2	3.3	3.3
Wheat /2	87.0	119.3	140.2	164.0	61.1	88.5	3.2	3.2
Paddy rice /2	171.2	235.3	274.8	318.6	60.5	86.1	3.2	3.2
Secondary cereals /2	127.5	179.7	213.5	255.0	67.5	100.0	3.5	3.5
Roots	107.9	136.5	153.4	171.6	42.2	59.0	2.4	2.3
Sugar (Centrifugal raw)	23.9	36.9	46.7	59.3	95.2	148.1	4.6	4.6
Sugar (No centrifugal)	10.8	13.5	15.3	17.4	42.1	62.0	2.4	2.4
Vegetables, nuts, oil seeds	32.4	44.7	52.8	62.3	63.0	92.2	3.3	3.3
Garden vegetables	69.7	99.4	119.3	142.4	71.1	104.3	3.6	3.6
Fruits	73.4	107.5	130.4	157.3	77.5	114.2	3.9	3.9
Meat /3	21.1	32.2	40.6	51.7	92.1	144.4	4.4	4.6
Beef	9.6	14.0	17.3	21.5	80.1	123.8	4.0	4.1
Sheep and lamb	2.6	4.2	5.5	7.1	110.9	174.4	5.1	5.2
Pork	3.5	5.3	6.6	8.3	88.0	135.5	4.3	4.4
Fowl	2.3	4.1	5.6	7.9	143.6	241.1	6.1	6.3
Eggs	2.8	4.5	5.9	7.7	112.4	179.7	5.2	5.3
Fish	12.3	19.0	24.3	31.4	98.7	155.9	4.7	4.8
Whole milk, including butter /4	93.7	137.6	168.4	205.8	79.6	119.6	4.0	4.0
(Skim milk)	(13.6)	(20.2)	(25.1)	(31.1)	(84.9)	(129.4)	(4.2)	(4.2)
Cheese	2.6	3.7	4.5	5.5	75.0	112.6	3.8	3.8
Fats and oils /5	9.9	14.8	18.5	23.0	84.9	129.4	4.2	4.2
Butter (fat content)	1.1	1.7	2.1	2.5	81.4	122.6	4.1	4.1
Vegetable oils	7.7	11.7	14.5	18.1	87.6	133.6	4.3	4.3

SOURCES: For 1969-71, OCDE, Statistics of food consumption; and FAO, Accounts of food utilization, Statistics Division; for 1980, 1985 and 1990, FAO estimates.

/1 All of the data for food demand has been rounded off. /2 Includes the demand for non-food items expressed in primary product equivalents. /3 By-products included. /4 Dairy products included in liquid milk equivalents. /5 Animal fats included.

TABLE 9. PHYSICAL LOSSES OF SOME FOOD PRODUCTS DURING THE POST HARVEST PERIOD /1

PRODUCT /2	COUNTRY	PERCENT OF LOSSES	CAUSES
Corn (1)	Colombia	20-45	Condensation, insects diseases
Sorghum (2)	Colombia	15-60	Condensation, insects diseases
Barley (2), (3)	Colombia	12-45	Diverse
Wheat (3)	Mexico	12-29	Diverse
Beans (4)	Colombia	15-75	Condensation, insects diseases
Chick-pea (4)	Colombia	18-60	Condensation, plagues diseases, etc.
Vetch (4)	Colombia	23-65	Condensation, plagues diseases, etc.
Rice (5)	Colombia	16-45	Condensation, plagues diseases, etc.
Rice (6)	Philipines	10-37	Condensation, plagues diseases, etc.
Potatoes (7)	Dominican Republic	12-50	Diverse
Potatoes (8)	Colombia	25-48	Diverse
Tomatoes (9), (10)	Colombia	35-70	Diverse
Plantain (11)	Colombia	28-65	Diverse
Casava (12)	Colombia	40-75	Diverse
Onion (9), (10)	Colombia	15-38	Diverse
Pineapple (13)	Cuba	40-50	Plagues, diseases
Oranges (15)	Florida, U.S.A.	15-30	Plagues, diseases
Pineapple (15)	Colombia	35-70	Diverse
Strawberries (11)	California, U.S.A.	14-48	Disease
Sweet potatoes (17)	Puerto Rico	50	Plagues, diseases
Mulberry (9)	Colombia	35-90	Diverse
Sorghum (19)	Congo (Afr)	50-70	Insects
Grains in general (20)	North and South America	5-50	Diverse
Corn (21)	Tanganyika	80	Insects
Corn (22)	Georgia, U.S.A.	11-37	Insects
Grains (23)	Peru	10-18	Diverse
Grains (24)	Mexico	15	Diverse
Grains (25)	Ecuador	20	Diverse

/1 In many cases reference is made to local studies and not to total losses in the country of reference
/2 The number corresponds to the source reference

and 33 percent of all food produced in the world is lost (28). This would mean annual losses between 400 to 675 million metric tons of food. 1/

If we restrict our analysis to Latin America and exclusively the production of energetic foods, and of those rich in protein and vitamins (28), total food losses would be on the order of 38 million metric tons annually. That is to say, an amount equivalent to more than twice the volume of total food imports by all Latin American countries in 1974 -- valued in excess of US$5,000 million dollars. Assuming that a more or less balanced ton of food could feed 3 persons during a year, we are theorically losing food sufficient to feed more than 45 million persons.

Continuing with our analysis and reviewing once more the figures shown in Table 7, which indicate that there are approximately 36 million persons in Latin America and the Caribbean with serious malnutrition problems, we can conclude that the possibilities to resolve at least part of this food problem may be within our reach. And that by taking the necessary steps to greatly reduce the post-harvest food losses we could likewise be helping to meet a portion of the annual increase in food demand.

II. THE ACTUAL SITUATION IN POST HARVEST FOOD SYSTEMS ANALYSIS

Figure 4 represents the post harvest system and some of the stages through which a product moves between harvest and the final consumer. According to several authors (3, 9, 40, 45) many general observations can be made

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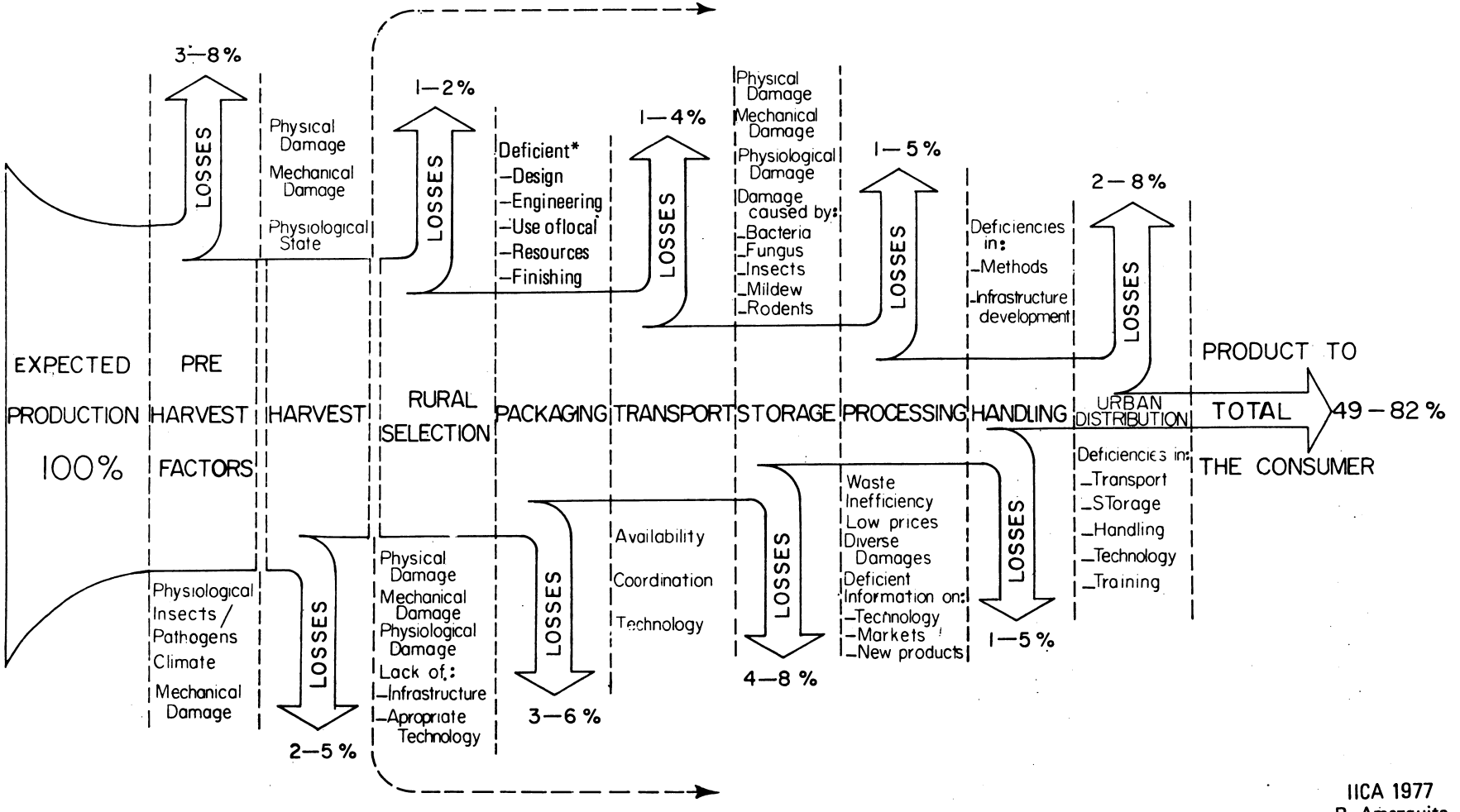
1/ Calculation based on total volume of world food production.

FIGURE 4: STEPS IN THE POST HARVEST SYSTEM
% LOSSES AT EACH STEP



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here:

a) The post harvest system is a complex process made up of many variables which affect the final result.

b) In it intervene the technical as well as social and economic aspects.

c) Those affected, either positively or negatively, include all those who intervene in the system, and through them, the country itself. (Figure 8).

d) Taken as a group, the food industry is the most important in the world in terms of volume, value and number of persons employed (37).

Many authors point out that in our medium, and from the technical, social and economical points of view, the steps in the marketing process do not happen nor succeed each other under a harmonious and ordered process, but are interrupted and or restricted by deficiencies which often lead to negative results (3, 7, 9, 38, 40). The final result is an inefficient use of agricultural production and of considerable losses in both effort and product (3, 33, 18).

Some of the most common deficiencies in the marketing system are:

a) An inadequate organization of marketing channels to meet the countrys needs.

b) A deficient use of available technology during harvest, selection, packing, transportation, storage, conservation and distribution of food products.

c) Lack of knowledge (or nonexistance) in the national institutions of research programs and poor desemination of new technologies in the sciences associated with marketing.

d) Lack of services, guides or information regarding prices, markets, standards, etc.

e) Deficient, and at times nonexisting, infrastructure to carry out, under minimum conditions and quality control, the interchange and handling of agricultural products.

In, Figures 4 and 5 we see that concepts and technologies of diverse sciences or disciplines intervene directly or indirectly in the marketing process. These include: Engineering; Agronomy; Chemistry and Biochemestry; Food Technology; Economy; Sociology; Ecology; Administration; Politics, and others.

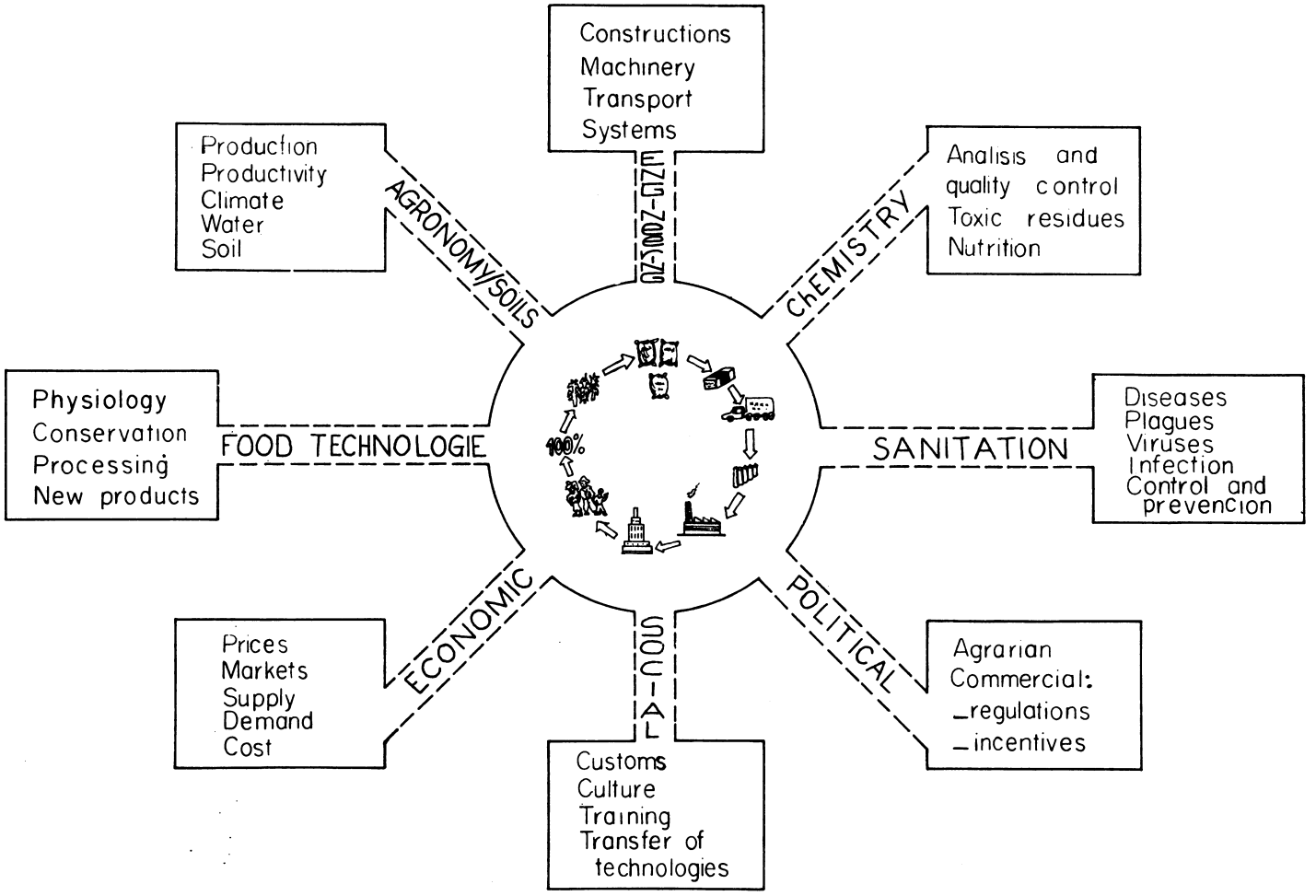
How and with what effectiveness have the intervention of these disciplines been in the marketing process, especially in efforts to reduce the post harvest food losses?.

In the United States, Canada, Europe, Australia, Japan, and other developed countries there are excellent teaching and research centers concerned with different aspects of post harvest problems. The results have been highly beneficial for the respective commercial systems, however, in Latin America the situation is very different.

a) In most of the Latin America and Caribbean countries there are very few institutions dedicated to investigating and solving problems related to post harvest food losses.

b) The participation of the diverse sciences mentioned above has been in general fragmented and individualistic by discipline, specialization, or areas of interest, consequently, the problems are resolved on a case study basis, under the misconception that partial solutions

FIGURE 5: MULTIDISCIPLINARY FIELDS INVOLVED IN THE MARKETING OF FOOD



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will resolve the faults of the overall system (41, 42).

c) Some disciplines participate only superficially or are not taken into account at all, resulting in too low levels of priority assigned to important areas, or misorientation of solutions.

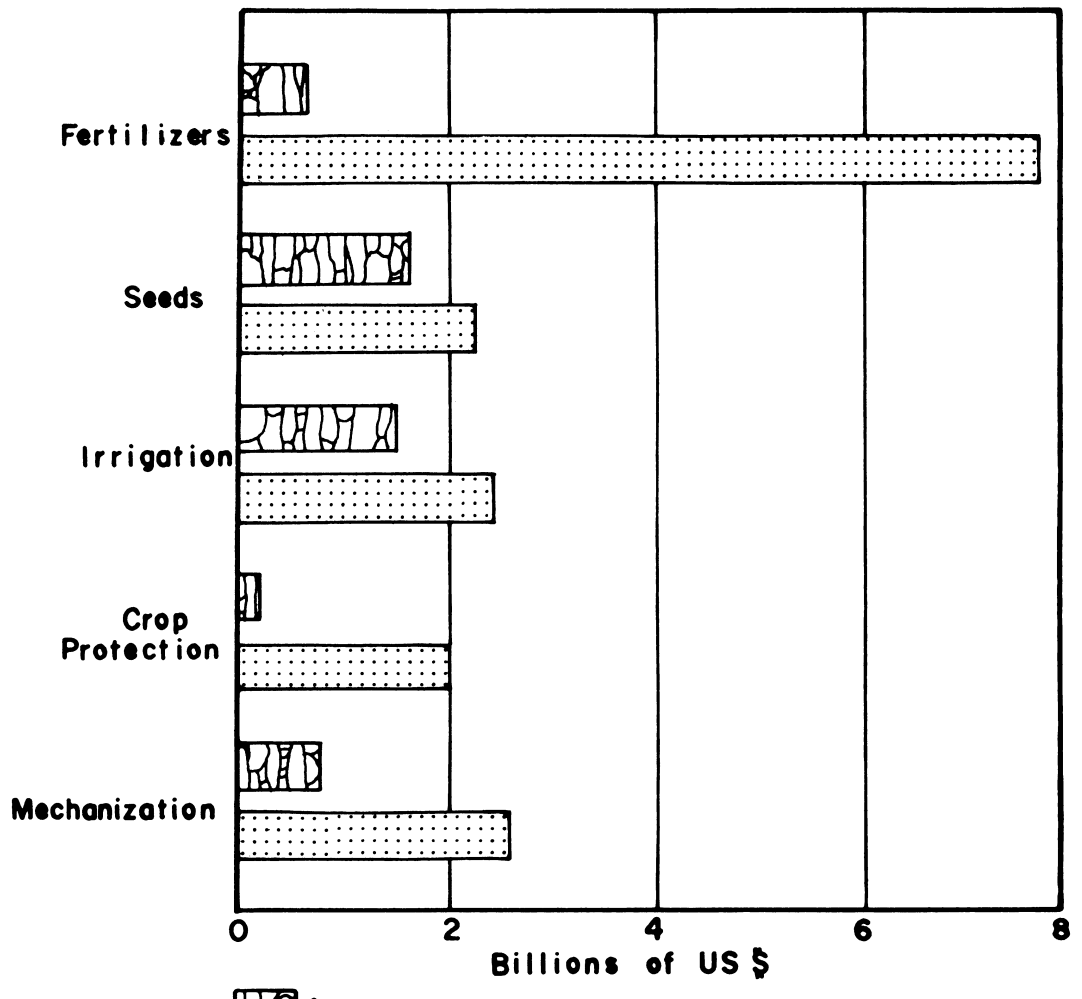
d) Individually, by discipline, works are carried out, some of them yielding excellent results. Nevertheless, and especially in the field of research, the "scientific hobby" and/or the "contribution to international science" tend to prevail over approaches towards finding real solutions to national problems.

e) Even though numerous works and technologies have been developed in other countries, their direct application in the developing world has met with many problems. This is often due to the fact that technologies are often developed under special conditions or for specific climates, ecologies, economies, ideologies, cultures, etc.

f) In the world in general, and especially in Latin America and the Caribbean, human and financial resources dedicated to resolving problems of post harvest losses are very limited and at times nonexistent. Figure 6 clearly shows the great disparity which exists between resource allocation for crop production and for post harvest activities (crop protection). The situation turns even more dramatic if we consider that in the case of crop protection (4 percent of the total of invested resources) investments made in agricultural inputs such as insecticide and fungicide (pre harvest costs) are also included.

g) In Universities and intermediate educational centers, minimum emphasis is given to post harvest activities, processing and agroindustrializa-

FIGURE 6: VALVE OF FARM INPUTS FOR WORLD AGRICULTURAL PRODUCTION 1962 AND 1985.



Source: Un Plan Agrícola Mundial. Boerna A.H.

Los Alimentos. Selecciones de Scientific American W.H. Freemand Co.-1973

tion. Libraries, laboratories and information centers often lack materials and services, which quite frequently leads to duplication of research and investigations already carried out elsewhere.

h) Preliminary research indicates that in Central America and Caribbean countries few national institutions consider the post harvest loss problem from a systems point of view. On the contrary, in the best of cases there is a tendency to concentrate on specific aspects of the problem, which may be neither the most limiting nor the most important in the solution of the problem.

i) Due to the lack of an adequate conceptualization of the problem (39), except in some individual cases, it follows that there cannot exist adequate national policy, nor an adequate institutional strategy and organization to direct remediable actions through well elaborated programs and projects.

III. A METHODOLOGY FOR THE ANALYSIS OF POST HARVEST FOOD LOSSES.

Many of the aspects which shall be mentioned in this chapter are derived from experiences in the Dominican Republic and Colombia (4, 7, 9, 10, 33). The general guidelines of the methodology (44) are the same as those followed in post harvest loss studies conducted in these countries, consequently it can be said that a great part of this methodology has already been field tested, under real world conditions and with very favorable results.

The purpose of this chapter is to clarify some basic concepts; to propose a definite methodological approach, and to delineate the most important steps and aspects for the implementation of diagnostic studies which will yield a

realistic image of the amount, nature and cause of food losses. Once this type of information is available it will then be possible to identify and prepare specific projects to reduce the food losses. General guidelines for identifying such projects will be discussed.

3.1 Objectives

The specific objectives of this manual are the following:

1. To provide some basic elements related to approach and criteria so as to facilitate basic investigation and to estimulate a better and more in-depth understanding of the post harvest loss problem.
2. To propose a step-by-step methodological approach to identify the most important technological deficiencies in the internal marketing system and the different kinds of food losses.
3. To propose some criterion useful to quantify, in a realistic form, post harvest food losses originally intended for human consumption.
4. To suggest some important considerations for the identification and preparation of development projects to reduce food losses.

3.2 Post Harvest Life of Foods

As with all living organisms, fresh food is made up of tissues and/or cells in which occur the physiological and pathological processes associated with life. These cells breath through a series of complex reactions in which essentially the fats, starches and sugars, stored

in the tissues with the presence of oxygen, are converted to carbon dioxide and water. The energy released from this process is used in part for the reactions and activities related to the maintenance of life while the other part is dissipated in the form of heat.

Up to the present time no technology has been developed which can completely detain the deterioration process in food, whether fresh or processed. Consequently, once food enters the post harvest state it begins a process of continuous deterioration, and the success of marketing depends in great part on the capacity and effectiveness of the marketing system and the methods used to slow or reduce the speed of the processes which cause the deterioration.

Most of the chemical reactions in fresh food products are regulated by the catalitic action of the enzynes. The activity of the enzynes is in turn partially regulated by the temperature and tend to increase from two to four times for each 10°C rise in the medium where the reaction takes place.

For this reason temperature is considered the most determining factor in the deterioration of food products and consequently in the potential post harvest life. The second important factor, especially in the tropics, is humidity. For example, a high humidity favors the growth of fungi, moulds and bacteria in basic grains. On the contrary, a low humidity, or the combination of high temperature and low humidity in the environment, can create conditions in which fruits, vegetables, tubers, roots, meats, etc. lose a great amount of weight due to dehydration and consequently suffer in terms of quality and appearance.

The proper temperature and humidity control, depending on the product being handled, are the two most important factors which directly or indirectly have the greatest influence in the post harvest life of foods.

Other pre and post harvest factors which have considerable influence in the post harvest life of foods are discussed below. They have some inmediate manifestations such as changes in form, color, soluble solids, texture, etc. These manifestations are the reflections of reactions and complex processes which are taking place in the product and which finally accelerate the deterioration process and terminate the post harvest life. Many of these factors are a function of conditions occuring during the growth and development processes of the products. Consequently it is very important to remember the strong interelationship which exists between the three stages of: Production, Harvest and Post-Harvest. In the vast majority of the cases, the physiological makeup and the conservation quality of the products depend in great part on the favorable or unfavorable conditions during the stages of growth and development.

It can be said that once the foods are in the post harvest stage the most to which we might aspire is to conserve their quality, not to improve it. In some particular products such as banana, pear, tomato, meat, and others, conditions can be created which will transform some chemical substances into others of greater preference to the consumer. But in order to be able to do this and obtain a good quality product, we must begin with excellent quality raw materials, as other-

wise it is practically impossible.

3.3 Definition of Terminology and some Basic Concepts

Part of the existing confusion in the evaluation of post harvest food losses is due to the absence of an established and accepted terminology and/or well defined criteria concerning the different aspects of this problem. To help alleviate this problem the following definitions, which have proven useful elsewhere (4, 7, 9, 11, 12, 33), are proposed.

3.3.1 Food

Any substance that serves to nourish a living being (43, 54). In this case two types of food shall be distinguished.

a) Those destined for human consumption

b) Those destined for animal consumption

For the objectives of this document only the foods destined for human consumption shall be considered. Those parts of food, such as bones, peels, skins or unpalatable tissues will not be considered as food for human consumption.

3.3.2 Production

The first stage in the cycle: Production-Harvest-Post-Harvest includes all those activities, from the selection and preparation of the genetic material, which gives origin to the new product (seed, animal, fowls, etc.), until the final product, be it stems, leaves, flowers, seeds, fruits, eggs, milk, meat or other, reaches its optimum state for harvest.

3.3.3 Harvest

Those activities or actions carried out to separate the product from the stock, stem or whatever originated and nourished its development (to gather the corn, wheat, vegetables, eggs, to milk, to sacrifice the cattle, fowls, etc.).

3.3.4 Post Harvest

This is the condition in which a product finds itself and the activities carried out with it once it has been separated from the stock, stem or from whatever originated and nourished its development.

3.3.5 Loss

Means any change in the chemical or physical properties that directly or indirectly affects its quality and makes it unusable for human consumption. Losses may occur at any of the three points: production, harvest, post harvest.

3.3.5.1 Production (Preharvest) Losses

These include damage caused by insects, fungi, birds, rodents, etc., during the growth period of the product (fruits, seeds,stems, etc.)

In the case of animals, sickness or disease problems causing death or deterioration of the product (milk, eggs, meat, etc.) are examples.

3.3.5.2 Harvest Losses

This type loss includes physical or mechanical damage caused to the grains, fruits, roots, stems, eggs,

milk, meat, and others during their harvest or slaughter.

3.3.5.3 Post Harvest Losses

All those losses which occur after the product has been separated from the stock, stem or other medium which originated and nourished its growth. 1/

3.3.6 Kind of Losses

According to Bourne (34), post harvest losses in food products can be classified as follows:

3.3.6.1 Direct Losses

Those caused by waste or consumption by non-human agents, such as insects, rodents, birds, fungi, bacteria, and others.

1/ 1. Fruit, vegetables, roots, tubers, grains, etc. are in the post harvest phase once they have been separated from the mother plant responsible for their development, with the objective to be used for human consumption, whether on-the-farm consumption or for sale.

In all cases, the situation may exist whereby the cause of future deterioration is present although in a latent state, thus without visual manifestation of damage. As explained in section 3.2, many causes of post harvest losses originate due to conditions developed during pre harvest. In these cases the loss may be classified as ocurring in post harvest from pre harvest causes.

2. Animals, birds, etc. are in the post harvest state once they have been slaughtered and the product enters the marketing process. As in the preceeding case, it can occur that defects found in the product are not identified during slaugher even though they are a result of preslaughter conditions. In such cases the veterinarian should decide on the classification of the loss depending on the damage and its cause.

3. Milk enters the post harvest process during milking, fish upon being caught for human consumption and eggs upon being collected.

3.3.6.2 Indirect Losses

These refer to deterioration in quality or acceptability of the product up to the point of complete rejection by the consumers. For example: changes in its appearance, texture, color, etc. caused by climate, improper handling, transportation, infraestructure, or others.

3.3.6.3 Economic Losses

Those losses brought about by changes in market conditions and expressed in economic terms. Includes losses due to changes in supply and demand.

3.3.7 Cause of Losses

Although in many cases it is very difficult to determine the exact cause or the principal agent of some types of damage, especially that due to physiological deterioration, or that due to a combination of causes, for the purpose of post harvest loss analysis the following classification system is proposed:

Causes of Food Losses with Technological Origin

1) Physiological damage (41, 49, 57, 59, 60, 65, 66).
2) Damage caused by agents or chemical and biochemical reactions (50, 51, 63, 64, 65).
3) Damage caused by biological or microbiological agents (48, 49, 52, 56).
4) Mechanical damage (67, 71, 72, 73, 74, 75, 76).

Causes of Food Losses with Socio-economic Origin

1) Political (1, 2, 5, 6, 28).

2) Resources (1, 2, 3, 4, 5, 8, 9, 10, 18, 23, 25, 28, 33, 37, 39, 40).

3) Education and training (1, 2, 3, 4, 5, 6, 7, 8, 33, 40, 47).

4) Services (38, 39, 40, 47).

Figure number 7 presents the diverse causes and the way in which they influence the respective parts of the system. In this figure the causes with socio-economic origin are located at the peripheria and those with technological origin inside of the circle. Also, although without the intention of identifying all of the causes in their respective positions, after each event (harvest, transportation, storage) the possible cause which may be affecting said component of the system is identified.

In Figure number 8 some of the persons and institutions which intervene in diverse parts of the system and which may be directly affected by the diverse causes are visualized.

3.3.7.1 Causes of Food Losses with Technological Origin

Under this category we find those causes which occur due to deficiencies in concepts, methods, application or use of methods and lack of knowledge or non existence of the adequate technology, even though favorable socio-economic conditions exist for their application and execution. Some examples include the

FIGURE: 7: POST-HARVEST LOSSES

SOCIO ECONOMIC AND TECHNOLOGICAL ORIGINS

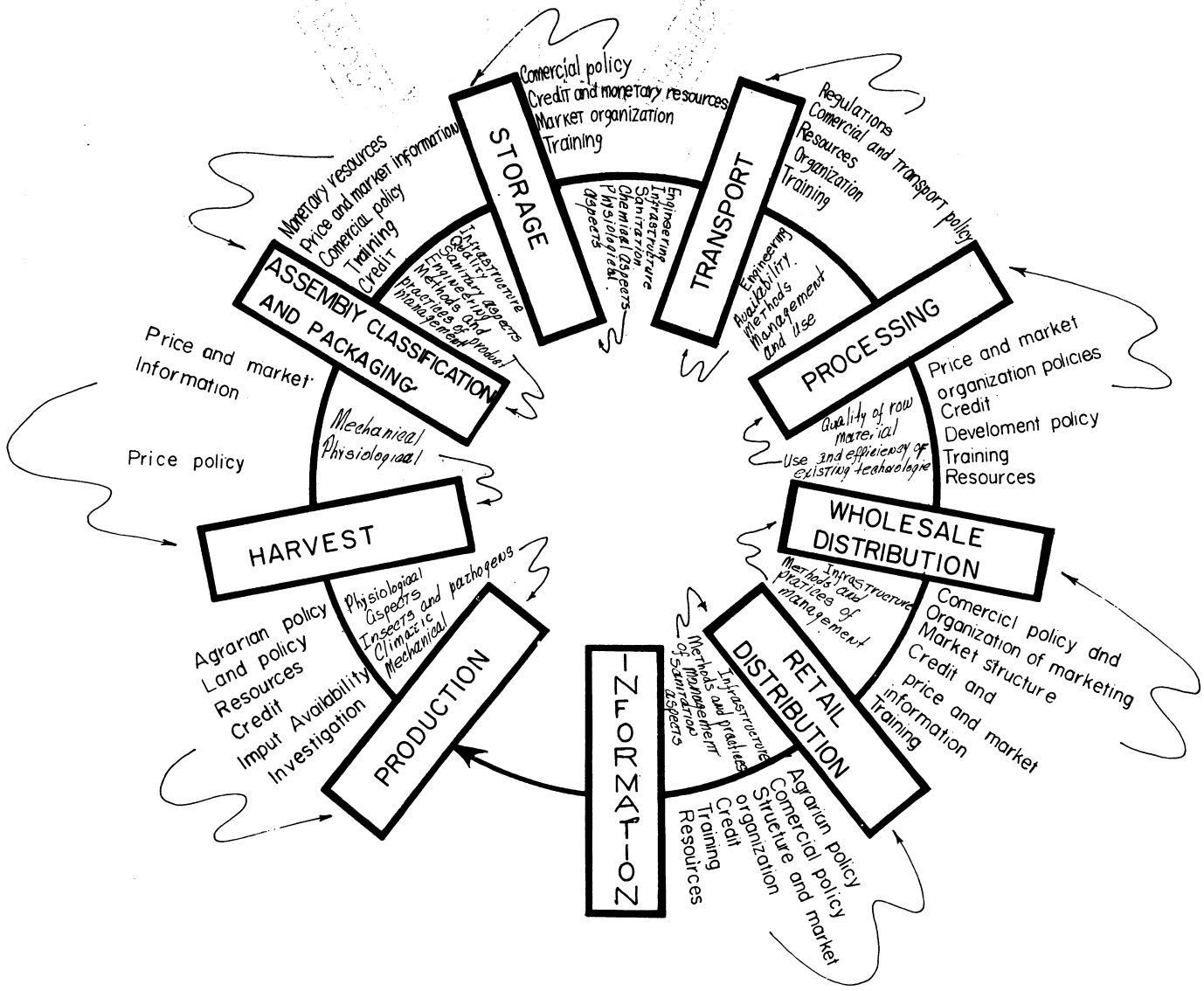


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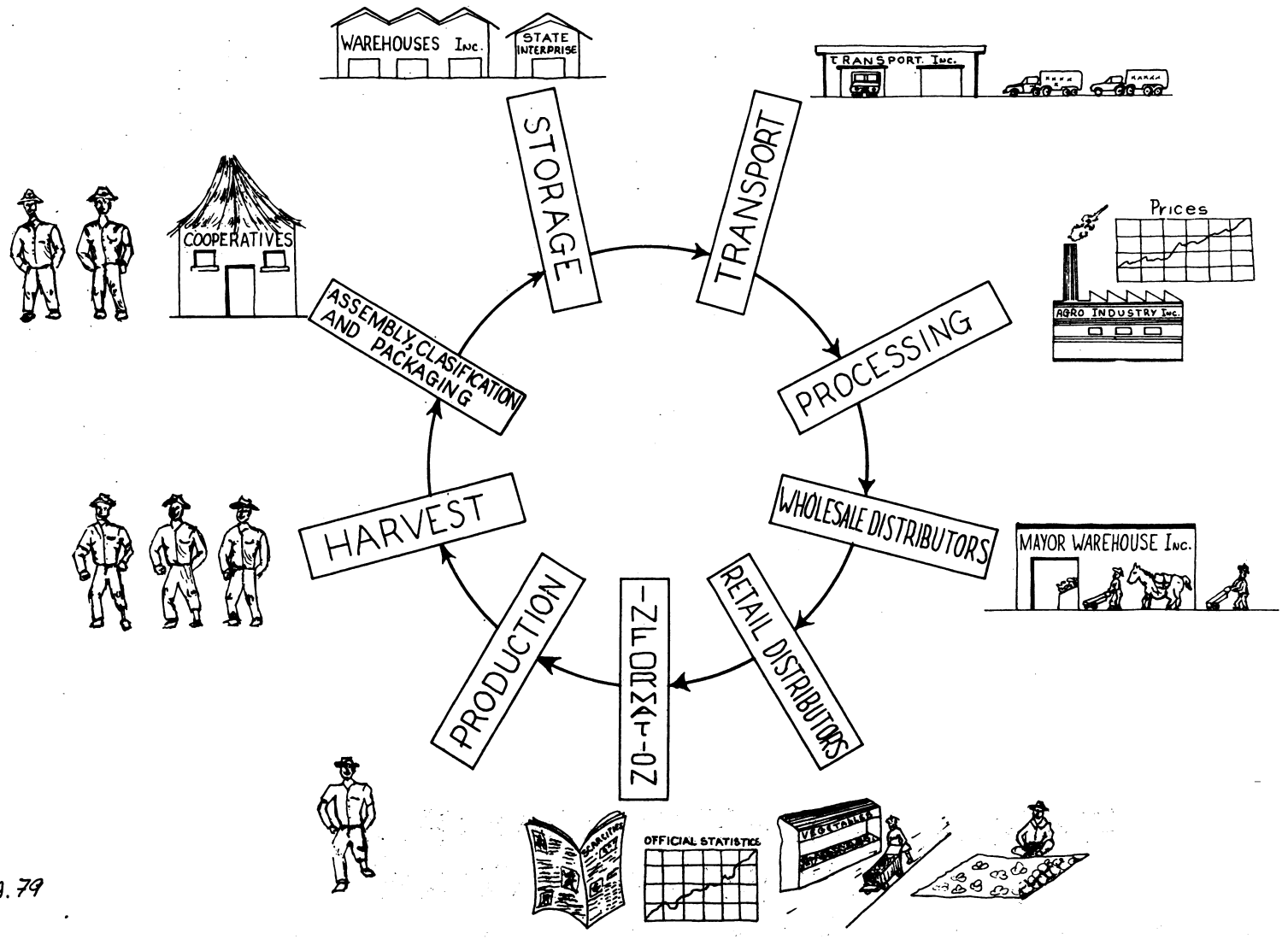
FIGURE 8: ORGANIZATIONS THAT INTERVENE IN THE PRODUCTION-MARKETING SYSTEM



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following:

Physiological damage

This cause of post harvest loss can be subdivided in two classes:

1) Normal deterioration which occurs due to the natural aging process of the products.
2) Abnormal deterioration, or that which occurs due to adverse conditions, such as, unfavorable climate, cultural practices, inadequate storage, handling, transportation, etc. and which lead to an accelerated deterioration of the quality of the product. Examples include: growth of suckers on tubers and bulbs during storage; the black heart of apples and potatoes caused by nutritional deficiencies or by improper storage conditions, and weight losses caused by dehydration and transpiration, notwithstanding that the phenomenom is of a physical chemical nature.

Chemical deterioration

This is damage caused by chemical or biochemical agents or reactions. This refers to those chemical reactions whose intermediate or final products are undesirable components or associated with significant losses in nutritional value. Examples include rancidity in fats and oils and the Maillard reaction of sugars.

The contamination by noxious substances, such as presticides or other chemical compounds, which are undesirable or harmful to the product or the consumer are also included in this category.

Damage caused by biological or microbiological agents. This includes losses due to such causes as insects, arachnidian, fungi, bacteria, moulds, virus, rodents, and other larger animals.

Mechanical damage

Mechanical damage can be caused by improper harvest methods, poor packing and transportation, resulting in cuts, abrasions, bruises, breakage, leakage, or other damage.

On occasions several different causes may act together to damage the product. For example, the damage caused by microorganisms is nearly always preceded by mechanical, chemical or physical damage which weakens the products natural defenses and thus facilitates attacks by fungi, bacteria or moulds.

3.3.7.2 Causes of Food Losses with Socio-economic Origin

In this case we have those causes which directly or indirectly lead to conditions in which a technological solution is difficult or inapropriate to apply. They are usually the result of nonexistant, inadequate, ignored or improperly handled conditions. Examples in this case in-

clude the following:

Policies

Lack of an adequate and properly oriented policy to facilitate, utilize and administer resources (human, economical, scientific, technical, etc.) to prevent product damage.

Resources

Lack of the adequate resources (human, economical, technical) to develop remediable programs and projects tending to reduce post harvest losses.

Education and training

Ignorance of scientific and technological techniques associated with the conservation, processing, packing, transportation and distribution of food products.

Services

Inefficient organization of marketing channels and marketing in general. Absence of, or inefficient, governmental services for production and marketing. Lack of credit in accordance with the needs of the country and the participants in the production-marketing system.

3.4 Methodological Approach

In reviewing studies in relation to marketing problems in Latin America one can conclude in general that:

1. There exists an advanced lack of coordination between the

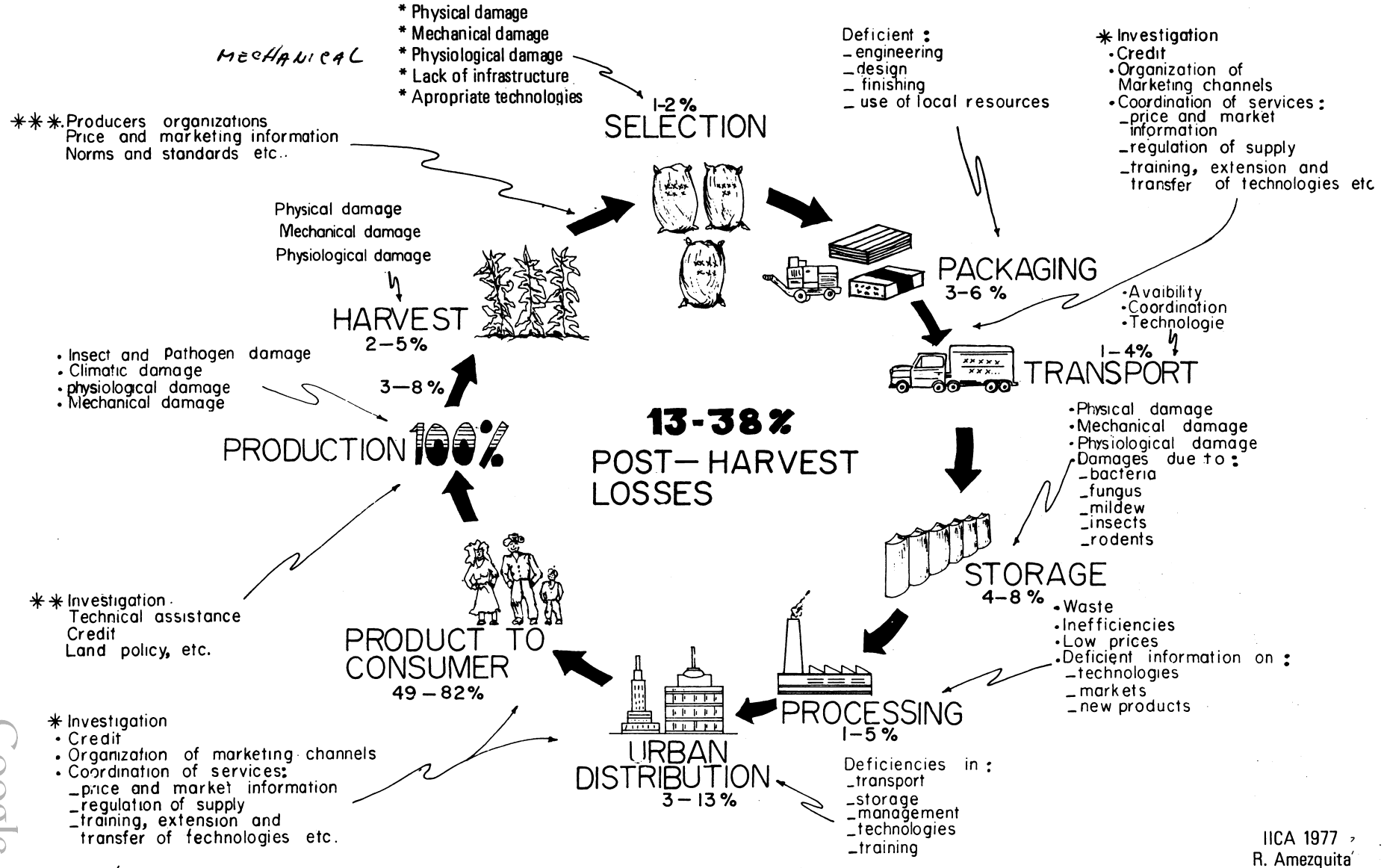
different steps of the marketing system and between the diverse participants in the system (40, 47).

2. The technical aspects of post harvest product management are very deficient in respect to handling, storage, packing, transportation and distribution of the product (9, 11, 40, 47).
3. There is a high degree of individualism in the approach and in the participation of the diverse disciplines in the few works oriented towards the solution of post harvest problems (39, 45).
4. There exists a distinct lack of national policies to carry out programs and projects to reduce post harvest losses (9, 39).

In Figure 9 we can once again visualize the complexity and the interrelationships between the different components of the "Production-Marketing" system, with special enfasis given to the technical aspects of post harvest, as well as in the diverse institutional, social, political, economical and other aspects which influence its behaviour. Said components or post harvest stages or processes can be categorized either as technical, (those whose variables are decided or measured on the basis of mechanical, physiological, physical, economic and even electronic concepts) or those related with social, cultural, institutional and political aspects of each society.

All of those steps or processes to which a product is submitted from the time and place of its collection up to the time and place of its consumption are considered components of the post harvest process. The sum of the components make up the post harvest system. This combination of steps should ideally occur within a harmonious process in which the

FIGURE 9: INTERPENDENCE OF THE PRODUCTION HARVEST/POST-HARVEST SYSTEMS



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product losses are minimized and the efficiency and benefit for the participating parties are maximized.

Up to this point we have tried to point out that post harvest activities should be considered as a complete system made up of diverse steps or components which are strongly interrelated.

The systems approach to understand, analize and to try to improve the deficiencies of the diverse components, has the great advantage of permiting either global or partial analysis of the respective contribution, behavior and efficiency of each of the systems parts. The systems approach also permits on orderly and logical analysis of alternative remediable programs or projects so as to define priorities. Otherwise, and as commonly occurs in many Latin American and Caribbean countries, well intentioned programs and projects are carried out with less-than-desired results because of the fact that decisions are taken under isolated conditions to resolve problems which are felt to be the cause of the problem but which in fact are not. Unfortunately, and after valuable national resources have been wasted, experience often shows us that a more efficient method is one of analyzing the post harvest loss problems using an approach which considers all the variables (or as many as possible) and their interrelations.

The systems approach has been proven time and time again as a useful and practical approach by countless medium and large private firms around the world, and more noteworthy, as an important component of the United States space program.

The systems approach is feasible whenever a model of the system can

be defined and its components can be described in quantitative terms which allow the formation of criteria concerning behavior and efficiency. Such is the case of the post harvest system. In the following section the methodological techniques for carrying out such an analysis of the post harvest system will be considered in more detail.

3.5 Mechanics of the Investigation

3.5.1 Definition of the Terms of Reference

The objective of research in the area of post harvest losses is to identify priority areas where: the reduction of losses is feasible and projects and programs can be developed to reduce such losses. Prior to investigation and/or any attempt to introduce new projects and programs it is necessary to analyze national governmental agricultural policies so as to define precise terms of reference which will serve as a guide in the realization of the studies, the analysis of the results and the definition of alternative solutions.

The criteria for such an analysis will vary with the country, local circumstances, ideology, orientation of local institutions and others but may include some of the following:

a) Agrarian policy; for example:

- self sufficiency vis a vis food imports.
- agrarian reform.
- increased productivity.
- increased production (new areas)

b) Special emphasis on crops;

- traditional vs. non traditional
- grains vs. fruits vs. vegetables vs. roots/tubers
- internal consumption vs. exports
- importance in terms of value or volume

c) Type of producers;

- commercial agriculture vs. agriculture for autoconsumption
- small farmers vs. large farmers
- organized producers vs. non organized

d) Geographical origin of the production;

- availability of basic infrastructure
- distance from urban areas

e) Other socio-economic aspects;

- human resources
- financial resources
- institutional capacity and interest

With the terms of reference established it is then possible to define such aspects as:

- what products to study?
- what volume to include in the sample?
- which geographical areas to consider?
- with what type of producer to conduct the study?
- who should participate in the investigation?
- what resources are available?

3.5.2 Steps to be Taken

The balance of this document is concerned with the general steps to be taken in the implementation of efforts to diagnose and analyze post harvest losses of food products and to propose remediable projects to that respect. This is a general guideline to which the necessary adjustments must be made according to the country, product, region, available resources, etc. Nevertheless, it must not be forgotten that with this methodology a systematic analysis of the problem area is to be made in such a way that at a given time a model of the system can be constructed in which it may be possible to observe in a quantitative and qualitative manner the magnitude of the losses and their causes. Therefore, it can be said that one of the important objectives of the diagnoses is to obtain sufficient data so as to construct a model which, much like an X-Ray screen, will allow us to observe the whole system and how it functions. This same model will at a later point, after enrichment and development, permit an evaluation of the efficiency of the remediable programs and projects being implemented. In this way it will be possible to develop a useful tool to facilitate decision making with a higher probability margin for success than under traditional approaches.

The methodological approach presented here can be divided into 13 steps. These 13 steps with their respective objectives are summarized below:

STEP 1: ORGANIZATION OF INTERDISCIPLINARY TEAM

OBJECTIVE: To assure the participation of the diverse disciplines in the diagnosis of the problem area as well as in the analysis of the system and the definition of alternative solutions so as to avoid over-emphasis in specific disciplines and under emphasis in others.

Because of the diverse areas which intervene in the Post harvest system (Figure 5), it is advisable to initiate the investigation with the formation of an interdisciplinary team.

The specialties of the participants will vary with the circumstances but should include a nucleus of the following personnel:

- Agricultural engineer or agronomist
- Economist or agricultural economist
- Food technologist and
- Sociologist or anthropologist

It might be necessary on occassions to include specialists in other fields, such as: Civil engineering, industrial engineering, phytopathology, entomology, pesticides, etc. Since the problems to be solved are often intricate, and of an interdisciplinary nature, it is unlikely that satisfactory results will be obtained without the proper staff.

STEP 2: PROBLEM DEFINITION

OBJECTIVE: To establish in the clearest and most concise form possible the basic problem to be considered. This will require basic research including a review of national and international literature and interviews and discussions with persons having experiences and expertise in the area of concern.

The first step to be taken in the solution of a problem is to clearly and concisely establish the terms defining it. If the problem cannot be clearly defined, the chances are very slim that it may some day be resolved.

STEP 3: DEFINITION OF TERMS OF REFERENCE

OBJECTIVE: To establish a clear understanding of what is to be done, when and where.

As this kind of work may influence political, socio-economical and technical decisions, it is very important to establish clear terms of reference in accordance with the ideology and philosophy of the country, institutional needs, government strategies and policies, etc. (see 3.5.1).

STEP 4: DEFINITION OF OBJECTIVES AND GOALS

OBJECTIVE: To effectively plan the work procedure to be followed.

The objectives may be of several different types, including:

- Economic (maximize output)
- Social (favor marginal groups)
- Technological (investigation so as to develop new and better methods or systems, etc.) and
- Political

When establishing the objectives vague statements or ambiguity should be avoided. Objectives should be as precise as possible, and each should have specific goals. Each goal should be defined with even

greater accuracy, including time periods for completion. Estimates should be realistic and based on existing capacities and human and financial resources. Once the goals have all been reached the objective will have been achieved.

STEP 5: CRITICAL ANALYSIS OF THE PROBLEMS AND GOALS

OBJECTIVE: To verify the rationality and utility of the proposed goals.

Before initiating the field work one should analyze the goals in detail, asking the question whether they are feasible and sufficient to achieve the objectives and if the available resources are sufficient.

STEP 6: CHOICE OF PRODUCT(S) AND GEOGRAPHICAL AREA

OBJECTIVE: To make a preliminary evaluation of the material needs and the magnitude of the work to be carried out.

Based on established criteria, Government policy, objectives, goals and available resources (human, economic, available time, technology, information, etc.) the products to be studied must be selected, as well as the geographical areas to be covered. This step will be made easier by reviewing the literature and studying documents or results of surveys related to the products or geographical regions of concern. It is recommendable, at least at the beginning and while gaining experience, to work with only a few products and small geographical areas, however, they must be representative of the regions, producers, products and marketing systems to be studied.

STEP 7: GENERAL STUDY OF THE MARKETING SYSTEM

SUB STEPS	OBJECTIVES
a) Visits to wholesale and retail markets	Detect visible problems, defects, damages, physical conditions, infrastructure, packaging material, transportation, and handling methods. Converse with participants in the system and obtain their impression on how it functions.
b) Preliminary determination of product flow; Consumer to Producer	To initiate the preliminary version of the flow diagram and plan the activities of the field work.
c) Preliminary preparation of forms to be used.	i) Determine the information to be obtained. ii) Define areas of investigation. iii) Determine the way and methods to obtain data in accordance with available resources (time, personnel, equipment, budget, etc).
d) Pre-test of forms at wholesale and retail level.	i) Verify applicability, difficulties and make necessary changes. ii) Verify levels, authenticy, the ease of obtention of the information and test the methods for data analysis.
e) First visits to production area	i) Direct observation of operations including: cultural practices, harvesting techniques, selection and classification methods, product packaging, handling and transportation. ii) Test forms and make necessary contacts and arrangements. iii) Identify the principal steps in the product flow diagram. iv) Detect the possible points for analysis of post harvest losses.
f) Preliminary study of the product as it passes thru the diverse steps between harvest and final distribution.	i) Preliminary analysis of the different steps (transportation, packaging, storage, handling, etc.)in the post-harvest system and the effects on the presevation of product life and quality. ii) Continue in the identification of specific steps in the product flow diagram.

iii) Identify areas and steps with specific problems and the possibilities for measuring losses.
iv) Determine with a certain degree of precision the points and methods for loss measurement.

g) Tabulation of data and primary information.
i) Verify if the choice of methods to obtain information is satisfactory.
ii) Confirm and define problems and work areas.
iii) Qualitative and quantitative analysis of the different data and circumstances under which it was obtained.
iv) Preliminary estimation of losses.

h) Analysis of primary information and decision making related to final work.
i) Based on the preliminary experience of the pre-test, which has been carried out and verified, define the final study design, units and methodology to be applied.
ii) Define sample size
iii) Define resources
iv) Define work plan

This is the first step in the identification and analysis of the diverse components of the marketing system and the steps, actions, activities and circumstances which occur at and between the components. As the main objective is to obtain a general but complete understanding of the marketing system it is suggested that the marketing system be studied in two directions:

- From the Retailer to the Producer, and
- From the Producer to the Consumer

It is suggested that the study begin in the direction from the retailer to the producer since at the retail and wholesale level one may observe, as though it were a photograph, the history of the handling that a product has received since it was harvested. Appearance, touch, taste and smell of the product at the retail level will provide, even to the inexperienced investigator, substantial knowledge as to the state of deterioration in which it arrives at the retail level and even a preliminary idea may be had of the causes of such damage. When carrying out

this overall reconnaisance of the marketing system, it is advisable to take into consideration the general technical aspects presented in Table 10 as they might help identify problems or causes of specific problems leading to product deterioration.

In Table 11 some of the potential problems are presented according to type of product and the point in the marketing system where they may occur. During this preliminary stage of investigation it is important to ask as many questions as possible concerning product origin, harvest season, on-the-farm storage, transportation and other situations which might help explain the condition of the product. One should not leave the wholesale/retail level without hearing the opinions of the intermediaries, businessmen, shipping agents, and others as to the main causes of the problems, suggested solutions, strengths and weaknesses of the system etc. As each new participant in the marketing chain is identified, key questions should be raised and discussed until his role in the post harvest system is understood.

This reconnaisance stage is very important, even for those with considerable marketing expertise, since the marketing systems can vary considerably from country to country and between regions, due to climatic, technological and social differences, as well as differences between products. It is therefore risky to generalize in this area.

Another important objective of this Step is to identify where, how and with whom the final study will be made. Without this information it will be impossible to go on to Step 8.

Once the investigator has reached the farm level (in his trek

TABLE 10 GENERAL TECHNICAL ASPECTS THAT SHOULD BE CONSIDERED AT EACH STAGE DURING INVESTIGATIONS IN THE MARKETING OF AGRICULTURAL PRODUCE

PRE-HARVEST STAGE	HARVEST STAGE	POST-HARVEST STAGE						
		CLASSIFICATION	PACKAGING	TRANSPORT	STORAGE	PROCESSING	HANDLING	DISTRIBUTION AND SALES
Appearance: -size -color Plant sanitation aspects Cultural practices Physical and mechanical damages Economic aspects Physiological aspects Climatic aspects	Physiological state: -ripeness -color, etc. Method: -manual -mechanical -chemical Product deterioration Economic aspects	Criteria Methods: -mechanical -physical aids Economic aspects	Design Engineering Materials Dimensions Weight Product protection Commercial aspects Economic aspects	Availability Methods: -animal -truck Physical conditions: -temperature -relative humidity -air movement Height of stacking Protection against bruises and impact Product deterioration Economic aspects	Product requirements: -temperature -relative humidity -air movement Composition of the atmosphere Infrastructure Engineering: -size -materials -equipment Form of operation and handling of the product Plant sanitation Product deterioration Economic aspects	Raw material supply: -volume -seasonality -price -quality Technology used Waste How quality of product determined Economic aspects Special problems	Methods and systems Conditions where carried out Deterioration of the product -physical physiological -mechanical Economic aspects	Methods and systems Product requirements: -temperature relative humidity -packaging Transportation and storage Infrastructure Product deterioration Economic aspects

TABLE 11 GENERAL PRE AND POST-HARVEST TECHNICAL PROBLEMS DIFFERENTIATED BY PRODUCT GROUP AND BY THE STAGE IN WHICH THEY OCCUR OR ARE MANIFESTED

TYPE OF PRODUCE	TECHNICAL PROBLEMS						
			POST-HARVEST				
	PRE-HARVEST	HARVEST	CLASSIFICATION	PACKAGING	TRANSPORT	STORAGE	WHOLESALE AND RETAIL DISTRIBUTION
FRUITS	Cultural practices and effects of the climate. Nutritional problems. Method of grafting. Use of chemicals	State of ripeness. Mechanical damages.	Physiological damage. Physical damage. Damage due to Micro-organism and insects. Damages caused by roedents. Damages caused by chemical products. Mixing of diverse sizes.	Over packaging. Inappropriate container. Mechanical damages due to poor handling or inappropriate container and poor handling	Mechanical damage due to: -inappropriate container inappropriate carteing. Inappropriate temperature. Inappropriate handling.	Chemical changes brought about by: -inappropiate temperature -improper relative humidity -inadequate aeration	Over ripeness. Turning black. Wrinkling. Micro-organism damages.
ROOTS	Effects of the climate. Cultural practices. Control of plagues and diseases.	Excessive humidity. State of ripeness.	IDEM	IDEM	IDEM	Inadequate curing. Germination.	Germination. Physiological damage. Micro-organism damage.
TUBERCULERS	Effects of climate Cultural practices: -system of irrigation. -frequency, etc. Effects of variety.	Mechanical damages State of ripeness.	IDEM	IDEM	IDEM	Inadequate curing Greening Germination	Germination. Infection. Wrinkling caused by dehydration. Mechanical damage.
LEAVES	Effects of climate. Cultural practices. Nutritional problems.	Wilting. Infection caused by excessive humidity.	IDEM	IDEM	IDEM	Wilting under low level of relative humidity. Insufficient humidity.	Excessive cuts. Excessive wilting Infections.
STEMS	Effects of climate. Cultural practices Management of water and nutritional problems.	Inadequate harvest methods. Mechanical damage	IDEM	IDEM	IDEM	Growing Fiber development.	Wrinkling. Other physiological damage caused by micro-organisms Mechanical damage
BULBS	Effects of climate. Cultural practices Seed management	Ripeness. Mechanical damage	IDEM	IDEM	IDEM	Germination Damage by microorganisms. Mechanical damage. Temperature and relative humidity during storage.	Wrinkling Germination Loss of color Microorganism damage Mechanical damage
GRAINS	Ripeness. Cultural practices Irrigation Effects of climate	State of ripeness Mechanical damage Excessive humidity.	Mechanical damage Damage due to microorganisms. Damage by roedents and insects.	Mechanical damage Physiological damage Damage due to: -Microorganisms -roedents -insects -poor handling	Mechanical damage Physiological damage. Inappropriate handling.	Chemical changes. Physiological deterioration Damage caused by Biological agents. Inappropriate management of facilities and structures. Weight losses. Contamination.	Damage caused by biological agents. Lost of viability Chemical changes Contamination Deterioration of containers.

from retailer to producer) and has gained a clear understanding of the mechanics of the system, it is then possible to carry out a preliminary study of post harvest losses, based on a small sample of the product of interest, from the farm gate to the retail level. Such sampling will require materials and special instruments [1/] that should be obtained before the field work begins.

During the study itself, and so as to record each one of the steps taken, actions or situations to which the studied product is submitted, from harvest to retailer, or final consumer, it is suggested that the format shown in Figure 10 be followed. This flow diagram methodology has often been applied in industrial engineering studies with considerable success. The example shown in Figure 10 is taken from the study of post harvest losses of tomatoes in the Dominican Republic (33).

The completion of the flow chart results in a process diagram which is the graphical representation (Figure 10) of the successive steps in the post harvest process, including: operations, transport, inspections, delays, and storage that occur during a process or procedure. Information considered convenient for the analysis, such as temperature

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1/ 1. 3-5 Watch thermometers (metal and long bulb) to measure temperatures between 20°C and 50°C
2. Rotating sicrometer to measure relative humidity.
3. Scale with capacity of 0-5 Kgs. and accuracy to 10 grams.
4. Scale with capacity of 0-25 Kgs. and accuracy to 25 grams.
5. Magnifying glass
6. Tape measure
7. Color cards to determine different shades
8. Razor
9. Plastic bags for samples
10. Plastic mesh bags for samples and measuring weight loss.

FIGURE 10: FLOW DIAGRAM

PRODUCT : Tomatoes

ORIGIN : Bani

DATE : May 2, 1977

RESUMEN

FUNCTION	No.	TIME
Operation	5	
Transport	3	
Classification	1	
Delays	3	
Storage		

	DETAILS OF FUNCTION	Operation	Transport	Classification	Delays	Storage	Temp. °F / °C	Distance	Time	OBSERVATION
1	Pick tomato from plant	○	△	□	D	⛛				
2	Tomato placed in 5 galon tin can	○	△	□	D	⛛				Tomato thrown in bucket
3	Tomato remains in can until container filled	○	△	□	D	⛛			5 min	Approximately 5 minute delay
4	Container carried to packing area	○	△	□	D	⛛		50M	5 min	Usually located under tree near fields
5	Container emptied	○	△	□	D	⛛				Tomatoes dumped in pile 2 feet high
6	Tomato awaits packing	○	△	□	D	⛛	85°			From 15 minutes to 3 hours
7	Tomatoes selected and packed in home-made wooden containers 80-90 lbs	○	△	□	D	⛛			15 min	Small, deformed and damaged are removed
8	Full crates carried to waiting point for truck	○	△	□	D	⛛		30M	2 min	Shaded areas, crates covered with grass
9	Wait for truck	○	△	□	D	⛛			10 hours	From afternoon to late night
10	Loaded on truck	○	△	□	D	⛛				
11	Transported to Capital	○	△	□	D	⛛	90°	40 Km	1 hour	
12	Un loaded at market place	○	△	□	D	⛛	90°		15 min	
13		○	△	□	D	⛛				

in fahrenheit or centigrade, necessary time required at any one point and the distance traveled, etc. may also be included.

According to the procedure of diagrams the activities are identified in the following manner:

OPERATION:

Those eventualities which a product undergoes and which prepares it for a following step, for example the act of harvesting a product, washing it, packing it, etc.

TRANSPORT:

Transport takes place when a product is moved from one place to another, except when such movement forms part of an Operation or is caused by the operator at the site during an Operation or an Inspection.

INSPECTION OR CLASSIFICATION:

This occurs when a product is examined to verify its quality, quantity or other characteristic. Also when the products are regrouped into different categories or classes.

DELAY OR WAITING:

This occurs when conditions do not permit or don't require the immediate execution of the following step. If there is an intentional delay so as to change the characteristics of the product then it would be classified as an Operation.

STORAGE:

This takes place when the product remains intentionally in a

specific location so as to protect the product from adverse conditions or while waiting for sale.

COMBINED ACTIVITIES:

When it is desired to show more than one activity executed by one or various operators at the same work site. An example of a combined activity is as follows: "The packers seated on the floor place the product inside of a container while at the same time observing the product to determine whether it is of the desired quality". Thus we have a combined activity of Operation and Inspection.

With the preliminary data which have now been obtained (Steps 1 thru 7) it is possible to have an idea of the magnitude of the problem which is to be analyzed and of the steps, arrangements, preparations, resources, etc. that will be required to carry out the analysis. Once these decisions have been taken and the work plan has been defined one can move on to Step 8.

STEP 8. CARRYING OUT THE FINAL DIAGNOSIS

OBJECTIVE: Obtain data for a complete and systematic analysis of post-harvest losses.

Given the complexity and the natural difficulties that will arise in undertaking some of the observations it is recommended that the following concepts be kept in mind.

A) Concept of Quality

It is very important before undertaking any evaluation to define the concept of quality existing in the geographical region where the study is to be carried out and between the different participants in the production-marketing system.

It is common to find diverse concepts, for example:

a) That of the producer, whose principal interest is to sell the largest possible quantity of his product, even though the quality of said product is questionable.

b) That of the intermediary, whose interest is to buy products of excellent quality but at the moment of purchase attempts to stress the defects of the product offered by the farmer.

c) That of the housewife, who at the end of the marketing chain looks for quality and prices to meet her budget.

d) That of the investigator or professional, who with experience in evaluation and quality control, takes a more scientific approach to quality.

Generally the concept of the investigator or professional is more detailed and complete, nevertheless, given the state of the art in which agricultural products are marketed in most countries, and where for diverse circumstances it would be very difficult to apply strict criteria, it is preferable and perhaps more realistic, for the objectives of this work, to apply a more general criteria of quality as visualized by those who participate in the real life marketing system.

In the case of those products whose deterioration and damage makes them completely useless for human consumption, there is little doubt about whether they should be classified as losses or not. However, the problem is not so simple with those products which are found at an intermediate stage and whose defects or deterioration have not reached the point where they can be classified

or quantified as losses. What should be done in these cases? Perhaps a general sample of participants in the commerce of the product of interest, with observations concerning opinions and concepts of quality and rejects, in periods of abundance as well as in periods of scarcities, would yield the necessary insights.

It should be noted that in those cases of chemical and biological contamination, or those yielding harmful wastes, the concept of the investigator or official charged with quality control should be the norm that determines the final classification of the product.

B) How to Measure Losses

Considering the definition of "losses" (see section 3.3), it is possible to think of innumerable variables and factors that affect the quality of the products and that could serve as parameters to measure the grade or intensity of the deterioration of the product and thus qualify the possible losses. In reality, numerous and excellent methods (41, 42, 46, 50, 51, 52, 53, 56, 57, 58, 59, 60, 61, 63, 64, 65, 66, 68, 69, 70) have been developed for these purposes, mainly by scientists and specialized technicians, to identify and solve specific problems within their respective disciplines. Some examples are the following:

a) Evaluation of the losses caused by (x) insects, microorganisms, rodents, etc. in a specific product (48, 49, 52, 56).

b) Physiological deterioration of (x) product during (y) time or (z) storage conditions (41, 49, 52, 57, 58, 59, 60, 61, 66).

c) Chemical changes (protein degradation, synthesis of sugar, acids, etc.) during (x) handling conditions, etc. (50, 51, 63, 64, 65).

d) Method for determining the microorganism causing (x) chemical changes in (y) product, etc. (49, 50, 51, 52, 68, 69, 70).

As to the terminology to be used in reporting the post harvest losses? In reality the technical and scientific literature abound with diverse units of measurement, including pounds, tons, kilograms, gallons, boxes, percentages, units of nutritive value, etc., which vary with the type, level and geographical location of the study. In fact, this diversity of terminology is undoubtedly one of the reasons for the existing confusion as to the real value or volume of post harvest losses.

Consequently, it is suggested that even though the inicial studies are made using the local terminology, the final report, whatever the cause of the losses, be prepared expressing the losses in one of the units of the metric decimal system (grams, kilograms, metric tons, etc.).

It is also recommended that whenever possible, and so as to have a more precise idea as to the magnitude of the losses, that the values be reported in percentage terms of the total amount produced or harvested in the zone, region, country, etc.

So as to have a greater level of accuracy in the quantification of the losses it is suggested that the specialist responsible for

determining the cause of the loss (entomologist, pathologist, agricultural engineer, veterinarian or other) make an evaluation as to the degree or intensity of the damage and with his (their) assistance determine in terms of weight and percentage the quantity lost.

Considering our definition of "food losses" (see 3.3) and the type of losses being evaluated in this type of study (food for human consumption), those foods which are determined unfit for human consumption, no matter what the cause of the loss, must be quantified as 100 percent losses even though the remainder may be usable as animal feed.

The basic reasons for this are:

a) The produce was originally destined for human consumption.

b) Although the product in a state of deterioration can be utilized as animal feed, the conversion rate for the majority of the animals is so low (generally less than 10 percent) that final results are not affected greatly by estimating it as 100 percent loss.

C) Taking the Sample

Considering the difficulties and high costs involved in evaluating losses by taking large samples, such as a full truck load, plus the additional inconveniences of getting the intermediaries to treat large samples as they would under normal circumstances, it is preferable to follow the examples set in the Dominican Republic and Colombia (7, 33, 44) of purchasing representative samples by random, and based on recommendations of statisticians. These samples (boxes,

crates, sacks) are purchased and evaluated at the farm gate under traditional conditions. Immediately thereafter the produce is introduced into the diverse marketing channels where it is periodically checked and evaluated as to losses and condition at predetermined points. Each individual sample should be handled in a random fashion, although care should be taken to assure that the produce is distributed throughout the carrier or warehouse or other point in such a way as to be affected by the traditional methods of handling and storage in a representative manner. It should be kept in mind that at any one point or step in the post-harvest system variable handling conditions for a product can exist. For example:

a) The container may vary in size, quality, cleanliness or other.

b) During transport, boxes or sacks at the bottom of the load receive different treatment from those towards the center or on top. Those on top will be affected more by rain and sun and those at the bottom by weight.

c) During storage the effects will vary depending upon:
   - The amount of sun vs. shade
   - Rapid vs. slow cooling
   - Protected by plastic vs. not protected
   - High relative humidity and low temperature vs. the inverse, etc. etc.

d) During wholesale/retail distribution the effects on the product will differ depending on:

- Rapid vs. slow turnover of inventories
- Satisfactory sanitary conditions vs. conditions facilitating contamination.
- Frequent vs. infrequent handling
- Adequate vs. inadequate infrastructure, etc., etc.

Due to the wide number of possibilities, it is easy to appreciate the large number of details to which attention must be given when evaluating losses. So as to avoid unnecessary complications and studies which are very difficult to terminate, it is recommendable to reduce the number of variables, at least at the beginning. So as to facilitate sample taking and to obtain more accurate results, it is a good rule of thumb to look for the average situation and conditions representing the majority and apply the analysis to these and not the extreme circumstances.

Those points most convenient for making evaluations of losses are those points as shown in Figure 10 where:

a) There are drastic changes in activity (one activity ends and another begins).

b) There are delays or at least sufficient time under the normal marketing process to evaluate, count, take notes, etc.

c) Special situations exist, after which it is considered prudent to evaluate the effect on the product (for example, after a certain time of exposure to existing adverse conditions such as sun, water, highway or transport over bad roads, by animal, truck, etc.).

In the product flow diagram presented in Figure 11, four points are identified with double asterisks showing where evaluations should be made. These are:

a) During the harvest

b) At the selection/classification point on the farm

c) While at the wholesale market

d) During the process of retail sales

At all of these points the investigator must exercise his ability of analysis to detect the type and intensity of damage and determine the technological cause of it.

The analysis in the wholesale and retail markets are extremely valuable as here it is possible to visualize the history of the post harvest handling of the product.

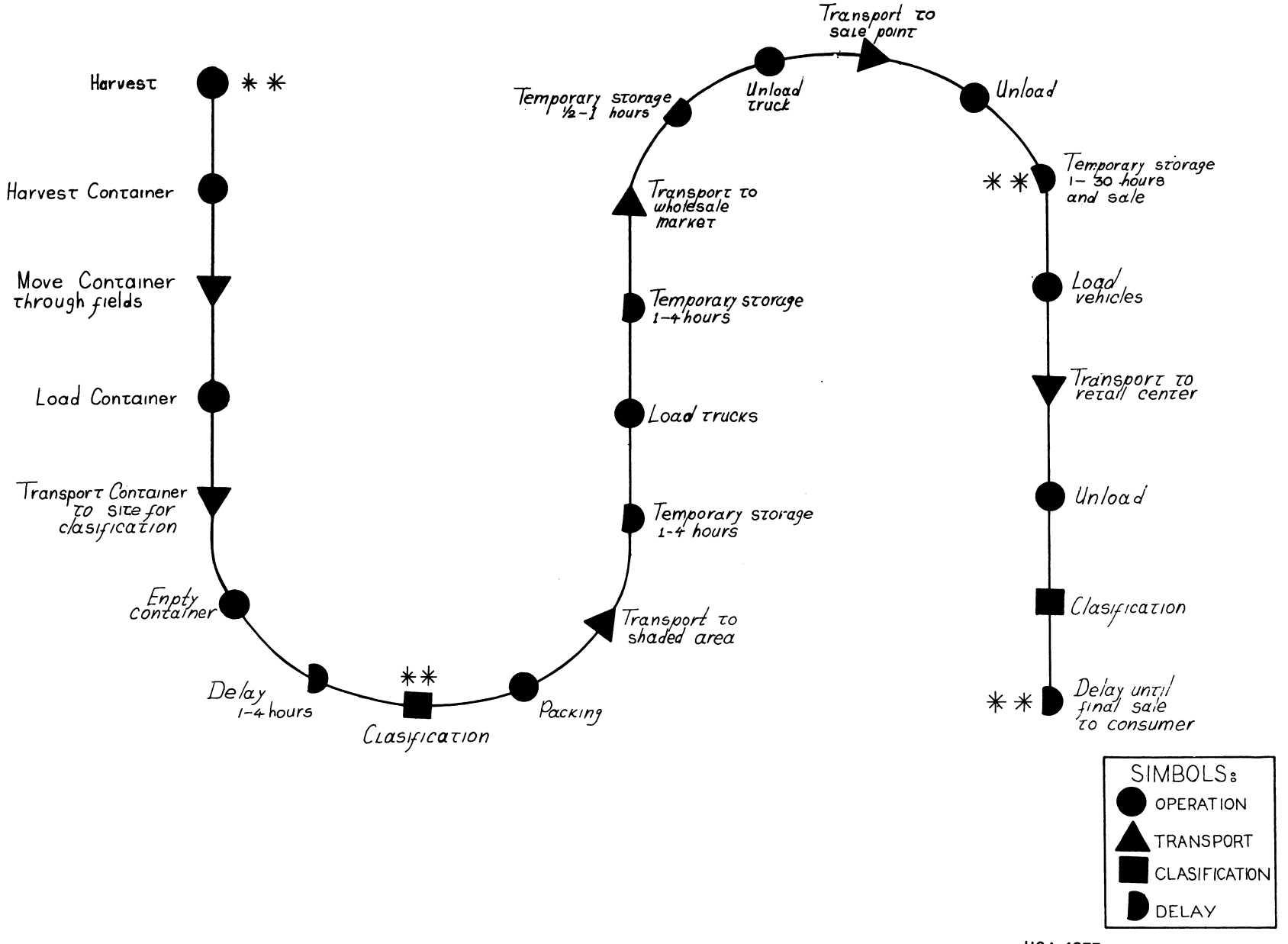
Since many of the visual manifestations of product deterioration, or physical, physiological or mechanical damage are often delayed several days, it is quite frequent for the product to arrive in the wholesale or retail markets before the damage becomes obvious. Consequently, it is at this phase of the investigation that a more precise judgement can be made as to the treatment received and effectiveness of each one of the steps or phases through which the product passes from the harvest to the final sale to the consumer.

STEP 9: TABULATION AND ANALYSIS OF DATA

OBJECTIVE: Analysis of quantitative and qualitative interpretation of post harvest losses and the determination of the causes.

To facilitate the analysis of the data it should be organized and presented in tables, graphs, matrices or other forms which summarize the general conditions of the overall system as well as each one of the

FIGURE 11: DIAGRAM OF PRODUCT MOVEMENT



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individual steps or phases thru which the product moves. The data should be analyzed along the lines originally planned for and in light of the conditions existing at the time that the evaluations were realized. It should be remembered at this point that, as observed in Figure 7, the causes for the food losses may be of a technological origin for which there may be diverse techological solutions, however, as it will be made clear later on the causes may also be of socio-economic origin which will require solutions of a non-technological nature. In keeping this in mind, it is therefore important to try not to reach final conclusions until the data has been reviewed and analyzed by one or more colleagues and by interested persons with fields of expertise or disciplines distinct from those of the principal investigator. This type of investigation requires an inter-disciplinary approach and corresponding interdisciplinary analysis of the findings.

In the interpretation of the data, especially percentage figures, the investigator should take particular care to avoid partial interpretations such as occurs when post harvest losses are a result of pre-harvest causes. Equally important in the determination of the causes for losses is to identify the immediate cause for the loss, and if there be more that one cause, to list them in order of occurrence.

The data which are tabulated and analyzed during this step and the resulting appreciations and conclusions derived become the new raw material which can be used to begin the design of a model for the post-harvest system.

STEP 10: BUILDING A SIMPLE MODEL

OBJECTIVE: Prepare a representative model for a quantitative and qualitative analysis of the system

The building of a dynamic model has several advantages:

a) It permits the rapid observation of aspects which cannot be visualized in any other way, given the complex interrelationship of the diverse components.

b) It permits the study of the behavior of the system under different conditions, without the inconvenience of changing the real life situation or interfering with the normal operating conditions.

c) In making these evaluations and experiments under a model situation it becomes easier to understand the complexity of the problem, which facilitates decision making and reduces costs for remedial projects and programs.

To develop a model, two things are required:

a) Know the purpose or objective of the model, and

b) Have a detailed understanding of the workings of the system.

The type of investigative research suggested in this document will produce considerable information on the particular post-harvest system studied. Although we are only at the beginning stage of understanding the magnitude and causes of post harvest losses, each individual study which quantifies losses will provide valuable information for defining product behavior. It is hoped that with the implementation of programs to identify, quantify and reduce post harvest losses of perishable produce in various countries, enough information will be made available so as to

design models which will permit the measurement of the effects of specific remedial projects and programs prior to implementation, thus reducing overall costs and facilitating decision making.

In Figure 12 one can observe the evolution of models over time. As the level of knowledge of a system increases the percentage of error decreases accordingly. The better we know and understand the post-harvest systems for perishable produce the easier it will be to define and implement low cost remedial projects and programs. Although considerable investigative effort is required before a post harvest model for perishable produce can be perfected, each new study helps identify important criteria and necessary steps which takes us one stage closer to remedial program design.

STEP 11: ANALYSIS AND EVALUATION OF POST HARVEST SYSTEMS

OBJECTIVE: Determine the principal variables that influence in the type and quantity of post-harvest losses.

Up to this point the methodology followed has permitted us to identify:

a) The principle participants in the marketing system of a specific product;

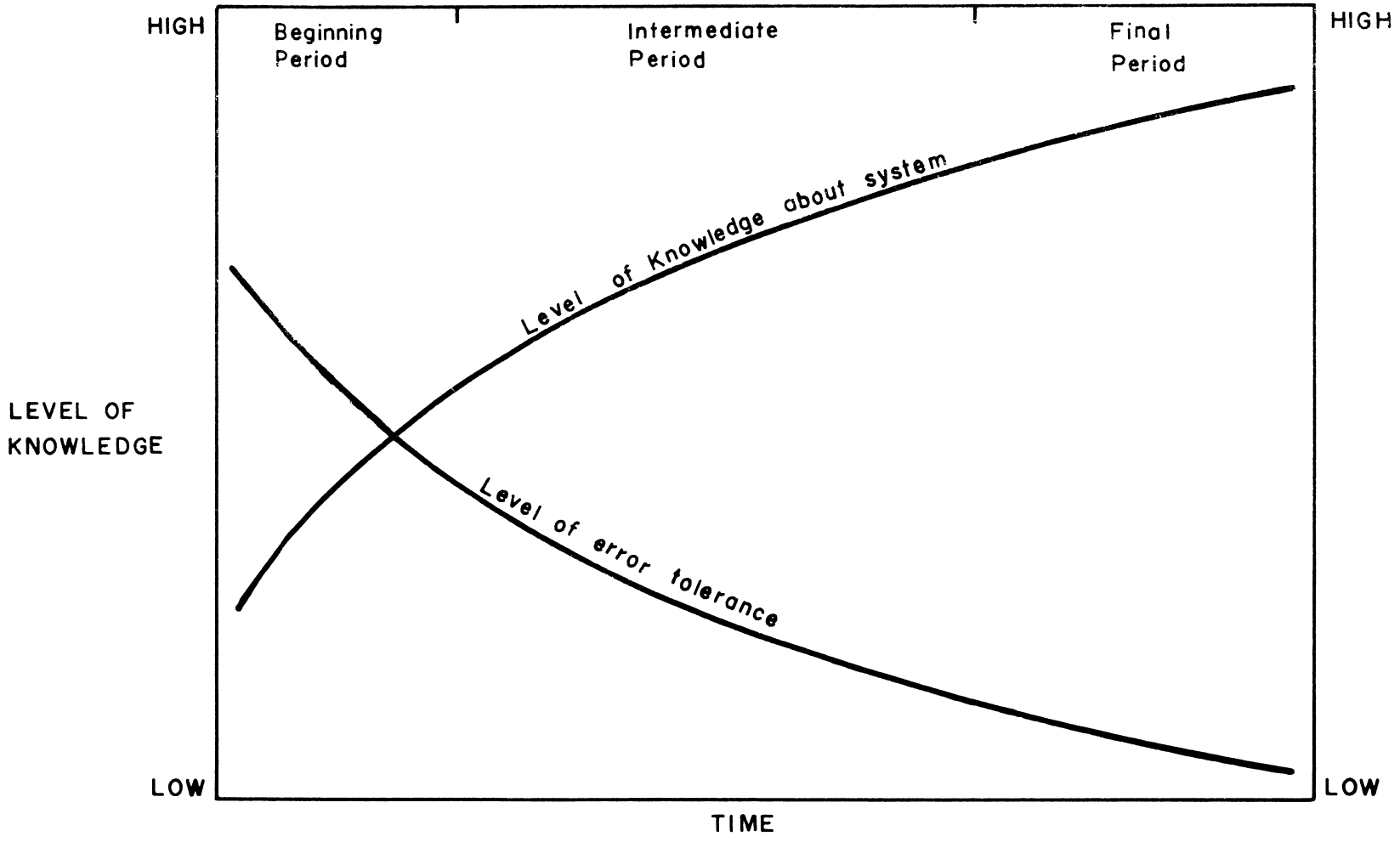
b) The principle causes for the post-harvest losses;

c) The percentage of losses at different levels and

d) Some alternative actions for reducing the losses.

Considering that the final objective of the investigation is the reduction of post harvest losses so as to improve the efficiency of the marketing system, it is necessary to analyze the diverse causes of the problem, the alternatives available to reduce the losses and the feasibility of introducing changes.

FIGURE 12: EVOLUTION OF MODEL OF POST HARVEST SYSTEM



To facilitate the analysis of this situation summary Table 12 can be used to identify the principle problems or causes for the losses, the necessary corrective actions, and the respective requirements in professional personnel and institutional support. The analysis of these diverse aspects will facilitate the definition of a program to reduce post-harvest food losses for one specific situation. Parting from the base that post-harvest losses are basically of four types: quantitative, qualitative, nutritional and germination, we can identify various causes. In the studies realized in the Dominican Republic in the cases of potatoes (7), tomatoes (33) and casava (78), the main problems identified were those of mechanical damage, physiological damage, and damage due to infection. These damages all negatively affect the quality and the nutritive value of the product. (See column 1 Table 12). The mechanical damages are a result of rough handling at diverse stages of the marketing channel (harvest, assembly, packing, transport, storage, wholesale and retail), or caused by badly designed or poorly finished containers.

The physiological damages are caused primarily by inadequate storage, too early harvest or delays occuring at some point in the marketing channel.

The damages due to infection are caused by insects and or microorganisms.

In addition to damages which are readily visible and can be linked directly to poor handling, improper storage or containers, insects, etc., there are other problem areas or causes for post-harvest losses which can be identified. These include:

a) Losses due to excessive production which may be caused by poor planning.

TABLE 12: IDENTIFICATION OF PROJECTS TO REDUCE POST HARVEST LOSSES

PROBLEMS AND CAUSES		CORRECTIVE ACTION *														PROFESSIONAL REQUIREMENTS **								
		Applied Investigation or Transfer of Technology		Training for		Extension for			Publication		*** Institutional Aspects		Infrastructure	Agroindstry	Others								
GENERAL	SPECIFY	General	Specific	Technicians	Producers	Producers	Intermediaries	Consumer	Direct	Indirect	Public	Private				Agronomist	Economist	Food Technologist	Anthropologist	Entomologist	Food Pathologist	Extensionist	Ag. Technician	Others
1. Mechanical Damages a) Rough handling: Harvest																								
Packing																								
Transportation																								
Storage																								
Wholesale																								
Retail																								
b) Container: Poor design																								
Poor finish																								
Other																								
2. Physiological Damages a) Storage																								
b) Early harvest																								
c) Delays																								
3. Infection a) Micro-organisms																								
b) Insects																								

* Indicate priorities of corrective actions by placing numbers in respective boxes, No. 1 is top priority.

** Include footnotes specifying how many professionals are required, why and possible source of.

*** Include footnotes specifying the role of the institutions, specific responsabilities of each institution involved and needs for inter-institutional coordination and integration.

b) Losses resulting from inadequate information on product handling;

c) Losses resulting from inefficient management by institutions and

d) Losses resulting from mismanagement of chemicals prior to or during harvest.

In the second column of Table 12 an attempt should be made to precise the nature of the problem, where it occurs (farm, transport, storage, retail) and the specific cause such as: improper packaging, rough handling, ripe fruit, etc.

STEP 12: IDENTIFICATION OF PROJECTS AND PROGRAMS

OBJECTIVE: Identify alternative solutions to the reduction of post harvest losses and determine their magnitude, potential import and requirements in financial and human resources.

Analyzing the principle causes for post harvest losses of agricultural products it becomes possible to identify alternative solutions to the problems. These solutions can be expressed in the form of projects and programs.

Traditionally, projects directed toward the reduction of post harvest losses have concentrated in the area of infrastructure; for example, cold storage facilities, silos, warehouses and agro-industry. Too often these infrastructure projects do not analyze the needs for training technical personnel and producers in simple methods of reducing post harvest losses, nor in the creation of necessary services at the institutional level to support the activities of the producer and the intermediary in the reduction of said losses.

The corrective actions which are most likely to lead to positive results require an integral approach including activities in: investigation, training, extension, communication and institutional integration in addition to infrastructure and agro-industry.

INVESTIGATION

In almost any program for the reduction of post harvest losses it will be necessary to carry out applied research and or pilot projects to study the possibilities of transfer of technologies before committing institutions and governments to nationwide programs. In those cases where basic information on specific products and their respective marketing systems is limited, the execution of studies of a more general nature are recommended so as to identify the principle participants in the marketing system, the points at which losses occur, the level of such losses, alternative solutions, etc. etc. These general studies will permit the identification of more specific areas where additional studies or pilot projects should be realized.

TRAINING

Experiences in the reduction of post harvest losses using a systems approach are quite limited. In most of the countries of the Caribbean and Latin America neither the technicians nor the producers have the experience or the training necessary in techniques of reducing post harvest losses. Any program to reduce post harvest losses therefore, should include activities, such as short courses and in-service training for the technicians active in the marketing sub-sector and, in specific cases, training programs oriented towards producers and intermediaries.

EXTENSION

The reduction of post harvest losses in a definitive manner for

most products is a very long process. Considering that in most countries, and for most commodities, there are thousands of producers, hundreds of intermediaries and millions of consumers, any program oriented towards the reduction of post harvest losses should include extension activities oriented towards these three groups of people.

COMMUNICATION

Together with the activities in extension and training one should consider activities in direct and indirect communication. Direct communication is that oriented towards specific groups, for example, the producers of potatoes, or retailers of Santo Domingo. Indirect communication is that which has a more general focus, for example, radio broadcasts, publications of price information in newspapers or pamphlets with general distribution.

INSTITUTIONAL ASPECTS

The success or failure of any program for the reduction of post harvest losses will depend largely upon the existance of institutions with a capacity to provide the required services in investigation, training, extension, publication and other necessary areas. In this analysis one should consider public institutions; such as, banks, Ministry of Agriculture, marketing organisms and others, as well as institutions of the private sector; such as, universities, foundations, farmer organizations, and others. The institutions are the key factor in the implementation of loss reduction programs because they are the source of the services as well as of the human resources responsible for the coordination and implementation of specific projects.

INFRASTRUCTURE

The infrastructure can be a very important element in any program to reduce post harvest losses, however, it is not important by itself

but as a part of an overall program. Any specific project that involves the construction of basic infrastructure should include the necessary needs in training, extension, investigation, publication, and others which will permit the infrastructure to function efficiently.

AGRO-INDUSTRY

Agro-industry, as a type of infrastructure, should also be considered from a systems point of view and not as an individual project by itself. Agro-industry requires a minimum production of raw materials of acceptable quality which implies organized production, training, extension and others.

PROFESSIONAL REQUIREMENTS

It is difficult, if not impossible, to find specialists in the reduction of post harvest losses This does not mean that qualified technicians do not exist in most countries in the fields of; food technology, entomology, economics, agronomy and others. The basic problem is that a specialist in the reduction of post harvest losses must be a combination of food technologist, entomologist, economist, agronomist, anthropologist, etc. It is for this reason that any program for the reduction of post harvest losses should not only be an integrated program but also a program designed and implemented by an interdisciplinary team.

Once the precise role of each of the above areas has been defined as part of the solution to the problem of post harvest food losses, the general outline of a program to reduce such losses will be apparent. With the help of Table 12 it will be possible to relate the possible corrective actions with the principal problems or causes

of the losses. In this way it becomes even more obvious that the solution to most of the food loss problems are neither isolated, nor easy, and require an inter-disciplinary and interinstitutional approach.

STEP 13: PREPARATION OF PROJECTS AND PROGRAMS

OBJECTIVE: Using a multi disciplinary approach and based on previous steps, prepare specific projects and programs to increase food availability through post harvest loss reduction and define the necessary steps for project implementation.

As has already been discussed, the principal problems identified in the investigations and their causes, are summarized in Table 12. For each problem identified the corrective actions should be listed by priority. These corrective actions can be organized and presented in the form of projects, or programs when there are more than one project.

The format to be followed in the presentation of the projects will vary with the anticipated source of financing. If the source of financing is, for example, a Development Bank then the guide for project preparation used by that institution for marketing projects should be followed. When project financing is derived from local sources then the project preparation guide should be adjusted accordingly. Nevertheless, whatever the source of financing for the project to reduce post harvest losses, there are a series of logical steps to be followed and specific information to be included. An example of these steps and the type of information required follows:

A) Definition of Problem

At this point it is necessary to summarize with considerable clarity the specific problems which the project is expected to solve. These problems may be described relating them to some of the following areas:

a) Prolems involving infrastructure (inadequate, too little, improperly managed, etc.)

b) Problems related to falty or inadequate services from state institutions (lack of information, technical assistance, training, financing etc.)

c) Problems with human resources (too few personnel, poorly prepared, low technical level, etc.).

d) Others.

B) Causes which Originate the Problem

In this section one should identify the constellation of factors which together are responsible for the problem defined above. It is seldom the case that post harvest losses are caused by only one factor. For example, damaged fruit at the retail level may be due to a series of factors including: lack of knowledge concerning harvest and post harvest techniques at the farm level; improper packaging, and rough handling. It is extremely important to identify all of the principal causes since these are the principal determinants of the Project (the solution to the problem) itself. The Project, to be successful, must include elements to eliminate all the major causes of the problem.

C) Nature of the Project

The purpose of this section is to define the type of project and relate how it is likely to solve the problem. An idea of the scope and dimension of the Project should be included.

D) Objectives of the Project

The objectives are oriented towards the solution of the problem(s) previously identified. They can be of two types: general and specific. The general objective is that which once obtained will eliminate the basic problem identified above.

The specific objectives should constitute a necessary and sufficient package to assure attainment of the general objective. This means that except for serious changes in the variables that fall outside the control of the Project, the completion of the specific objectives should automatically guarantee the attainment of the general objective.

E) Goals of the Project

Each one of the specific objectives implies the realization of a series of logically interrelated actions (goals). The efficient and timely completion of each one of these actions will assure the specific objective. From this point of view the goals are part of the specific objective.

F) Project Location

At this point one should identify the specific location of the Project including those points where construction will take place as well as the general area of influence.

G) Technical Aspects of the Project

In this section details on the technical aspects should be provided including some of the following: size; engineering aspects and investments: technical functioning of the Project; organization and administration of the Project; training and technical assistance, and others.

H) Financial Aspects of the Project

The financial aspects of the Project should include details related to: total cost; investments classified by category; sources of financing, and a calender of investments.

I) Institutional Aspects of the Project

The principal information to include in this section is that concerning the identification and description of the executing institution, as well as other participating institutions, and the description of the proposed method for interinstitutional coordination.

J) Socio-Economic Analysis of the Project

In carrying out the socio-economic analysis of the Project it is sometimes useful to relate it to other regional or national development projects of a complementary nature. The direct and indirect benefits of the Project should be quantified and evaluated. The effects of the Project upon distinct marketing aspects such as purchases, sales, transport, storage, agro-industry and others should be considered. Finally, the financial and economic return of the Project should be estimated.

K) Project Execution

As a final part of the Project a work and investment program should be outlined, as well as a calendar of investments and the description of the methods to be employed for Project control and evaluation.

The final step to project preparation is the identification and promotion of financial resources for project implementation. This step should not be left until last, however, but should be considered during the early stages of project preparation to assure that the project is prepared using criteria acceptable to the likely financing institutions.

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