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PESTICIDES IN THE GREEN REVOLUTION

UNIDO' ROLE

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PESTICIDES IN THE GREEN REVOLUTION.

UNIDO's ROLE

Corrigendum

Page 1, item 9, line 2

should read "increased rice yields'

Page 2, paragraph 5, line 5

Delete "merkets" and replace with "markets"

Page 4, Category 4, line 6

Delete "form and replace with "from"

Page 8, item B, line c

Delete "locally imported" and replace with "local or imported"

Page 11, line 2

Delete "Represenaitive and replace with "Representative"

Page 13, line 5

Delete "supplied" and replace with "applied"

Page 16, item 3, paragraph 3, line 1

Delete "giben" and replace with "given"

Page 17, paragraph 4, line 9

Delete "or" and replace with "of"

Page 18, paragraph 3, line 7

Delete "no" and replace with "not"

Page 20, line 2

Delete re-cycleing" and replace with "re-cycling"

Page 22, line 3

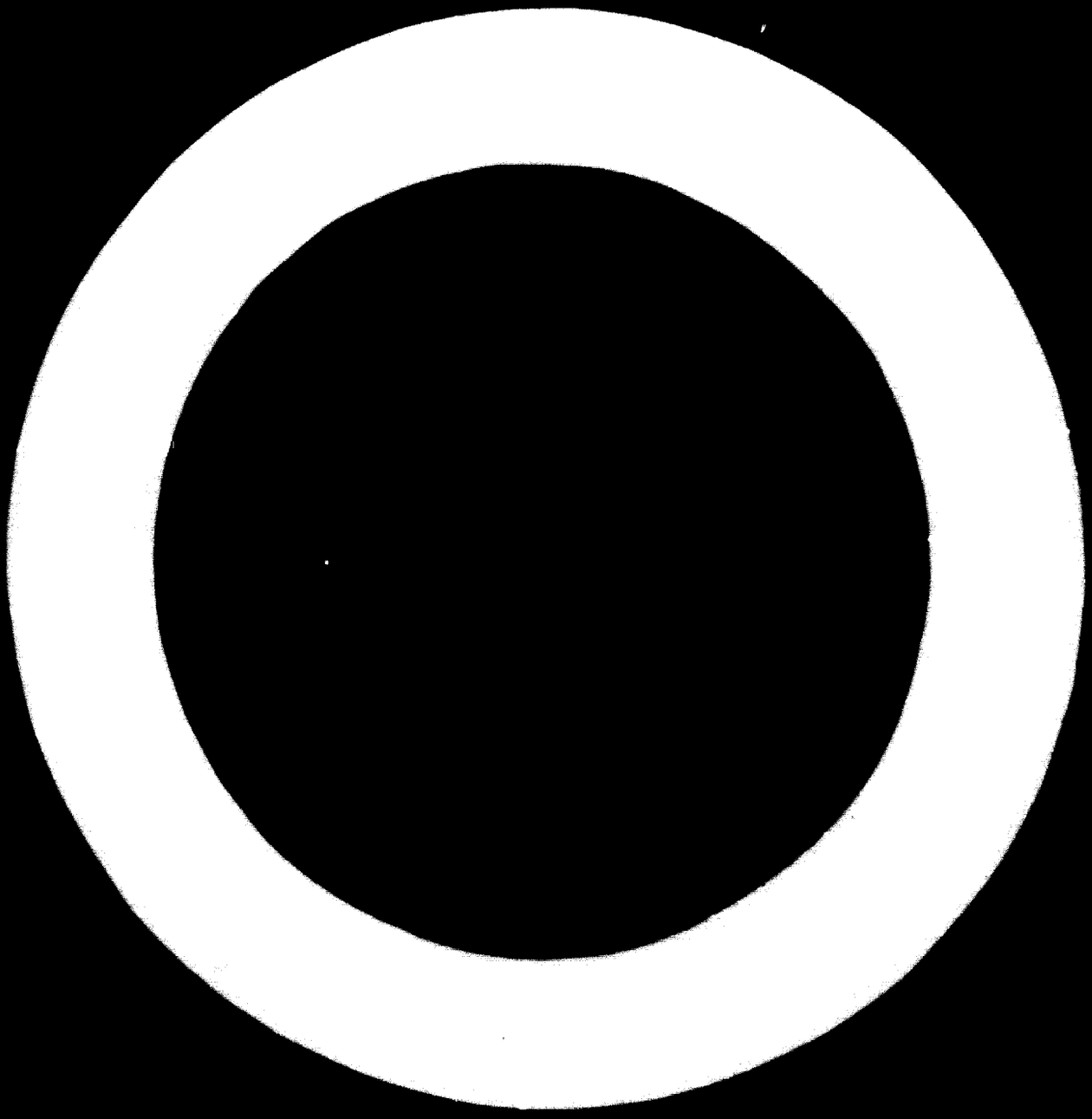
Delete "channrls" and replace with "channels"

Page 23, item g, line 2

Delete second "including"

Page 26, paragraph 5, line 2

Delete "by" and replace with "but"



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INTRODUCTION

Mankind has always had to protect his food, forests and livestock from the omnipresent threat of pests and disease which may reduce yields to the point where the production costs exceed the total value of the crop. It has thus been recognized that any significant increase in economic development depends upon an improvement in the yields of basic food crops and livestock, hence upon the control of the injurious diseases and insects that attack them.

Crop damage due to the depredations of insects, pests and diseases cannot be assessed reliably. Most of the available surveys and estimates put food losses due to insects and plant diseases at one-third of the total production. However, storage losses caused by insects and rodents and crop losses from weed competition are not included in this figure. Altogether, the total damage caused by pests may be as high as 30-50% of the total crop production. Economic considerations apart, this is an alarming figure in the light of the two-fold increase in the world's population forecast for the next forty years.

Some specific examples of crop losses due to pests indicate the extent of the economic damage:

1. Losses in potatoe yields due to late blight average 23% in Chile;
2. Rust disease frequently causes losses of up to 80% of the entire coffee production in Ceylon, 70% in South India and 30% in East Africa;
3. In the Philippines a plantation of 250,000 cocoonut trees was ravaged by an epidemic which left only 80 fruit producing trees;
4. In Sao Paulo, Brazil, 75% of the citrus trees, i.e., 4.5 million were killed by a virus in 1949;
5. Plant diseases killed 50% of the bean crop and 40-50% of the cantaloupe crop in Latin America, while corn rust caused 60% production loss in the same area.
6. Wheat stem rust destroyed 75% of the durum wheat crop in 1954 in the United States;
7. The cattle industry in Venezuela has declined 50% since World War II, from 20 million head to 10 million because of rabies transmitted by the vampire bat;
8. In the subtropical and tropical areas of Mexico, if weeds are allowed to compete with maize for only four weeks, the yield is reduced by over 50%;
9. In controlled demonstrations in Brazil, Pakistan and the Philippines, use of a selective weed killer (propanil) increased yields by 45-51% as compared with conventional weed control

Over the past decade, research has centred upon the reduction of pest damage by various means. Of these, the chemical approach using pesticides which are both economic and efficient has proved to be most successful in terms of immediate protection against a wide variety of pests. The return by way of increased crops, resulting from the use of pesticides, varies considerably but averages about five times the pesticide outlay.

The use of pesticides must increase at a rate commensurate with the increase of other inputs, such as fertilizers, irrigation, tools, etc. in order to ensure high returns on overall investments. The effects of new dams, irrigation canals or fertilizers are nullified if the resultant higher yeilds are not protected against natural enemies. This is a particularly important aspect of modern crop production in developing countries where agriculture has to bear the cost of industrialization.

The interdependence of agriculture and industry is, as a rule, strongest in the economies of developing nations. Agriculture supplies the labour force with food and industry with raw materials. Unless the country is exceptionally rich in mineral resources, agricultural exports must provide the bulk of the foreign exchange earnings needed to import capital goods required in the process of industrialization.

Agriculture provides industry with labour and financial backing. The agricultural population constitutes a market for industrial products, primarily for agricultural equipment and material, such as pesticides and fertilizers. It is of vital importance that each developing country maximise the efficiency of the foreign exchange earning sector of its agricultural production by utilizing advanced techniques, including the use of pesticides. However, if these materials have to be imported by tapping foreign exchange which would otherwise have been used to purchase capital goods for industrialization purposes, they are inevitably curtailed.

Industrialization is one of the main objectives of every developing country. However, in a number of countries experience has shown that neglecting agriculture can seriously jeopardize industrialization and economic growth as a whole. It has also been amply demonstrated that agro-based industries play an important role in the industrialization of developed countries and also have a beneficial feed-back effect on agricultural production itself. Agro-based industries are estimated to account for about half of the total value added and nearly two-thirds of the industrial labour force in developing countries. Consequently, it is recommended that local pesticide industries be established in those developing countries where agricultural productivity must improve to achieve a satisfactory level of food production, or where foreign exchange earnings are needed for industrialization.

Conditions permitting, integrated pesticide production including the manufacture of the most important intermediates, technical active materials and formulated end-products of large volume pesticide commodities (e.g. DDT, methyl parathion, 2,4-D eto.) would seem the best propostion. Unfortunately, conditions and size of merkets, availability of raw materials and know-how, high capital-investment requirements, etc. are unfavourable factors in most developing countries.

Problems and possiblities differ somewhat where speciality pesticides are concerned as they are manufactured and marketed as proprietary products under the protection of an effective patent, and high profit margins are incorporated in their selling prices.

The local manufaoture of speciality pesticides may be hampered, if the originating company holds a valid patent on the compostion, manufacturing or use of the product as the co-operation of the company holding the patent has to be obtained. This co-operation may take the form of a licensing agreement covering the transfer of technology and know-how, a joint venture or a direct and exclusive foreign investment. However, if the proprietary company refuses to co-operate, little can be done.

On the other hand, if no valid patent is involved, price structures could favour local production at a less than optimum scale despite the lack of raw materials. Manufacturing could consist of a single synthesis based on imported intermediates and their subsequent formulation.

Although some countries may not be able to consider the manufacture of technical active materials, they can still proceed with local formulation. Pesticide formulation is an essential manufacturing operation in which the basic pesticide (toxicant) is converted to a more suitable form for use in pest control. The operation comprises mixing ingredients from the classes of solid and liquid diluents, emulsifying agents, wetting agents, dispersants, deactivators, etc. The net result is a formulated product, which can be measured and applied accurately, with a high degree of effectiveness against the pests it has been designed to control.

The greater part of pesticide formulation frequently consists of diluents, in extreme cases amounting to as much as 98% or 99% of the finished product. Most countries have local sources of part or all of the inert diluents, even though they may not manufacture basic pesticides or surfactants. Potential foreign exchange savings through the use of local carriers and diluents is evident. Additional savings can be achieved by using local labour, and by strategically locating plants to reduce transportation costs.

Investment in formulation plants is not excessive, and a single suitably designed plant can formulate a wide variety of basic pesticides. Consequently, there is little danger of the fomulation plant becoming obsolete as compared with the cost inherent in the construction of a plant for a single basic pesticide.

UNIDO's Role in the Development of the Pesticide Industries in Developing Countries

The United Nations Industrial Development Organization (UNIDO) was established by the General Assembly of the United Nations to promote and accelerate the industrialization of developing countries and to co-ordinate the activities undertaken by the United Nations family in this field.

Enumerated below are some of the factors that developing countries may want to take into account when planning the development of local pesticide industries and an outline is given of how UNIDO can assist developing countries in achieving their goals.

Since there are widespread differences among the developing countries with respect to their general level of industrialization, it is convenient to deal with countries in four categories, as follows:

Category 1: Countries with no manufacture and incipient yet inadequate usage of pesticides;

Category 2: Countries with substantial pesticide demand and some existing distribution system but no local production (except perhaps for packaging units);

Category 3: Countries with sizeable pesticide markets and local formulation plants, but no production of basic pesticides;

Category 4: Countries with a high level of self-sufficiency and tending towards integration in the production of the most important products. Such countries may also have an active export trade and research facilities for developing new pesticides and adapting new technologies form the industrialized countries.

Category 1

The first category, consisting of developing countries with no pesticide manufacturing industry and a very modest current pesticide consumption, number some two or three dozen smaller countries, mostly engaged in traditional agricultural acitivities with a sizeable subsistence or non-market sector. The agricultural and industrial infra-structure is very weak or non-existent. The sale of pesticides within the country is in the hands of small shop-keepers who know little about toxicity, shelf-life or the proper application thereof.

Although the exact circumstances vary from country to country, it is believed that only in a few of these countries will the demand for pesticide increase sufficiently during the next decade to justify any manufacturing activities beyond simple repackaging and possibly some basic formulation of common pesticides with low toxicity levels. However, there are a number of steps that countries in this category can take with UNIDO assistance in order to improve the supply of pesticides, and thus the efficiency of agricultural crop production and the economy as a whole.

(1) Collect information of the country's potential pesticide requirements, carry out a cost and benefit analysis and prepare a forecast report for the next decade. FAO can be consulted and approached for assistance at this stage of development.

(2) Adapt or establish quality standards for all imported pesticides (in co-operation with FAO).

(3) Establish, if possible, a quality control laboratory to examine imported pesticides and check pesticide residues in export crops and food shipments. If the lack of facilities and trained personnel makes this impracticable, importers shall be required to produce certificates which can be checked together with the pesticide residues in exported food products by an institute in a third country. An alternative solution would be to establish a regional control laboratory.

(4) Provide training opportunities in developed countries for quality control technicians, while the local training of persons involved in the field application of pesticides can be arranged with the assistance of FAO or UNIDO.

(5) Organize a bulk-purchase scheme for important pesticides thus obtaining better financial terms, and at the same time set up packaging centres and an efficient distribution system by expanding existing channels or by creating new outlets.

(6) Examine the price structure and suggest suitable legislation to control exorbitant profit margins and other unfair trade practices to promote the use of pesticides. This can be done by a government authority in co-operation with UNIDO.

(7) Consideration should be given to the organized cropping and production of naturally occuring botanical pesticides such as rotenon (derris), sabadilla, ryania, quassia, pyrethrins, nicotine.

(8) Draft a legal provision pertaining to import quality control, price control and credit policies encouraging the use of pesticides, trade regulations for toxic pesticides, including proper warning, packaging and distribution of pesticides and the training of key personnel involved in the control, distribution and commerce of pesticides. Such provisions should also anticipate local manufacture and provide for its proper development and management.

Category 2

The second category consists of another two or three dozen countries, usually with a larger population and GNP than category 1, which are approaching the first stage of pesticide production. A very simple marketing and distribution system mostly exists, but few technicians are available in the sectors connected with the production, regulation and application of pesticides. There may be local filling or packaging facilities, providing limited employment but there are no formulation plants capable of producing the important products, hence these countries lack substantial economic benefits, such as:

(1) Substantial foreign exchange savings otherwise spent on diluents and transportation. (Diluents frequently represent 75-99% of the formulated products, thus their share in purchase and transportation costs can run quite high.)

(2) Reduction of local distribution and transportation costs through strategic location of plants.

(3) Increase in national labour input and purchasing power of the workers.

(4) Increase in farmers' competitive position.

(5) Reduction of risk of degradation in formulated products by speedier delivery.

(6) Generation of associated industries, such as the mining and processing of mineral fillers.

(7) Reduction of dependence on foreign suppliers.

(8) Restriction on the number of marketed products to avoid use of multiple trade names and resultant confusion.

Countries in this category would have annual pesticide requirements to the value of US$1 million or more.

UNIDO can offer assistance to countries in this category in the following areas:

(1) Market surveys to establish the demand for pesticides and to assess future market growth.

(2) Adopting or establishing quality standards for all pesticides (in co-operation with FAO).

(3) Establishment of a quality control laboratory to analyse all imported and locally produced pesticides before marketing and to check pesticide residues in crops for export. Developed countries have recently imposed very strict limitations and specifications concerning maximum permissible pesticide residues in imported agricultural products.

(4) Training in industrialized countries for technical personnel required to staff quality control laboratories or work in other pesticide fields (formulation, marketing, etc.)

(5) Correction of pricing structure through suitable legislation to combat unfair trade practices and to establish credit policies favouring increased use of pesticides.

(6) Feasibility studies for the establishment of local formulation plants, including the availability of local raw materials (diluents, carriers, etc.)

(7) Planning and erection of pesticide formulation plants including preparation of tenders and evaluation of bids for the selection of construction firms. Since the cost of a formulation plant varies from US$30,000 to US$300,000 depending on capacity and degree of versatility, consideration may be given to means of attracting foreign firms or organizations for joint ventures (See Annex A).

Category 3

Most of the countries have a relatively well developed infrastructure with industries concentrated in the urban areas. The distribution and marketing systems operate fairly efficiently and some countries may even have instituions dealing with the standardization and quality control of pesticides sold in the country, the prevention of accidents caused by toxic pesticides and the legal regulation of the sale of pesticides. All the countries in this category have pesticide formulation industries, the majority of which lack equipment and expertise in research and development of new pesticide formulations which are needed to take full advantage of the locally available raw materials.

The countries' annual pesticide requirements range from US$2 million upwards, depending on the area under cultivation and the population.

Some countries in this category may wish to extend their pesticide formulation industry to include the manufacture of certain special materials, as illustrated below:

A. Conditions and available information:

a) Demand for Product A (a selective herbicide for paddy) has been growing in a given country in this category located in a rice-growing region.

b) Product A is a patented speciality chemical selling for a relatively high price of US$4/lb, which has a braking effect on market expansions and severely curtails benefits to many of the small farmers in the region.

c) The company with the patent rights and production know-how would not consider building a local manufacturing plant because it wants to maintain full control and financial exploitation of the product for a maximum period.

B. Procedure

At the request of the Government, UNIDO would examine the possibility of establishing a production plant for Product A based on the information and expertise available in the following manner:

a) Possible market trends in the demand for Product A in view of new scientific and technical developments (new competitive products, potential resistance developed by important weeds, aspects of environmental contamination and degradation of pesticide residues, etc.)

b) Validity and duration of patent protection.

c) Availability of intermediate chemicals, locally imported.

d) Availability of production technology know-how.

e) Requirements and availability of local technical personnel and skilled labour.

f) Assessment of required capital investment and working capital for a specific production capacity.

g) Cost and price calculations with reference to the desired rate of depreciation and return investment.

h) Need for protective tariffs.

i) Source of financing.

Should the outcome of the above study indicate the feasibility of the project, UNIDO could further assist, if required, by:

j) Obtaining the co-operation of the original foreign manufacturer.

k) Preparing tenders.

l) Evaluating bids.

m) Contracting construction firms.

n) Scheduling implementations.

o) Supervising the execution of the project.

p) Training technical staff for the new plant.

q) Starting operations.

Generally, countries in this category could avail themselves of the UNIDO assistance in the following fields:

(1) Market surveys to increase or re-define local manufacture, which may indicate that local markets (i.e., regional markets) have grown sufficiently to justify a more diversified production sector. Strong pressure may also build up to increase domestic production and save foreign currency, even if the local production cost picture is not entirely favourable.

(2) Efficiency studies may pinpoint technical or organizational weaknesses in existing formulation plants, the elimination of which would subsequently increase the output of the production line.

(3) Studies to establish feasibility of production units manufacturing basic active ingredients and technical pesticides. A multi-purpose plant producing different ingredients in a series of production runs is sometimes feasible in cases where demand would not justify a separate plant for each product.

(4) Planning and erection of plants to manufacture one or more speciality pesticides of proven feasibility. Firms and organizations in industrialized countries may provide know-how and effect transfer of technology if appropriate and conducive steps are taken (e.g. suitable patent legislation giving adequate protection to foreign firms operating in the country).

(5) Assessment of the industry's export potential.

(6) Training of technical personnel to staff new production plants and quality control and pesticide residue laboratories.

(7) Organization of country-wide pesticide residue control for food export.

(8) Establish research and development laboratories to combat the problem of new pesticide formulations fit for local conditions and to exploit local resources to a maximum degree.

Category 4

Countries in this category are able to produce basic materials and formulated products to world market standards and to effectively distribute their products. They have well developed national plant protection systems, extension services and regional testi g laboratories. Depending on the size and population of the country, the national pesticide market is generally larger than US$10 million.

Countries in this category may undertake the complete synthesis and production of modern pesticides as they have the backing of a well developed chemical industry. A certain amount of applied research is carried out to facilitate the adaptation of other technologies, but this is often just supplementary to the work done in industrialized countries. A large portion of the domestic market requirements are satisfied by local manufacture, although special pesticides representing 10-50% of total pesticide consumption may still be imported. Furthermore, domestic products based on adopted technologies may find a lucrative export market in the neighbouring countries.

During the 1970's these countries may consider the following development objectives in the pesticide sector:

(1) Increasing the size and scope of research effort with a view to:

a) improving technologies in order to improve their position

b) developing modified or even original pesticides suited to the needs and raw material resources of the country.

(2) Develop or expand business, necessitating meeting world quality standards and a thorough survey of the potential export markets.

(3) Regroup or rationalise manufacturing units to achieve maximum efficiency and to reduce production costs.

(4) Develop a multi-purpose production or pilot plant for the production of experimental or small-volume products.

(5) Establish technical co-operation with foreign and international organizations in order to assure access to modern technical and scientific information and to expand product lines as justified by domestic requirements and export possibilities.

(6) Set up a pesticide residue monitoring system to safeguard environmental standards.

HOW TO REQUEST UNIDO ASSISTANCE

Procedures for the submission of requests for assistance vary from programme to programme. The UNDP Resident Representative will advise governments on these procedures. The following criteria, however, are common to all requests:

1. Assistance is granted only at the request of governments in a formal communication emanating from the central authorities.
2. Governments establish their own requirements and priorities
3. Requests of governments are submitted through the Resident Representative of the United Nations Development Programme, and transmitted simultaneously to UNIDO and UNDP for processing and approval.
4. A request may be formulated through the combined efforts of the national authorities and technical assistance experts, including UNIDO staff members, an industrial field adviser, and the UNDP Resident Representative.
5. Official requests normally contain a description of the project, its purpose and duration, the number of experts and the equipment required and the nature or amount of local costs and counterpart contribution to be provided by the recipient government.
6. The Resident Representative conducts preliminary negotiations with the requesting governments on the nature of the request and the source and availability of funds. Request for urgent short-term assistance may be made under the programme of Special Industrial Services, while medium-term advisory missions and pre-investment and pilot projects comprising experts, fellowships, and equipment can be financed through the normal procedures of the UNDP. Voluntary contributions made directly to UNIDO are also utilized in the establishment of physical and servicing units, among others.
7. UNIDO reviews and comments on the technical aspects of the request. If further information or revision is needed, arrangements may be made to assist the government in revising the request.
8. Recruitment of experts is undertaken by UNIDO in co-operation with the United Nations Technical Assistance Recruiting Service (TARS). Governments approve the proposed candidates prior to their appointment.

Model job descriptions for technical assistance requests are attached (Annexes B,C, D,E).

Annex A

FORMULATION OF PESTICIDES - A BRIEF SURVEY

Formulating operations are far more common than the manufacture of the basic pesticides themselves. This is not surprising since formulation plants can be installed much more cheaply than basic toxicant plants. They are applicable to a wide variety of pesticides, hence there is little danger of their becoming obsolete. Many of the raw materials are available throughout the world, favouring local manufacture with low transportation costs and a lesser drain of foreign exchange reserves.

There are several ways in which UNIDO can help developing countries to establish or improve specialized formulation operations:

1. Where no formulating facilities have been projected, UNIDO can assist in the basic analysis of benefits which could accrue to the specific country upon their installation.
2. Where countries have decided to install formulating facilities, UNIDO can advise on types of formulations, utilization of locally available ingredients, equipment requirements and plant layouts.
3. Even where formulation plants are already operating, UNIDO can organize specialized seminars on formulation technology and supply the services of formulation experts on a national or regional basis.

OBJECTIVES OF FORMULATION

Small quantities of toxicant cannot be uniformly applied over relatively large areas unless they have been diluted with a large quantity of solid or liquid material, such as talc, clay granules, petroleum oils or water. Application of several pesticides in a single formulation is quite common: it ensures uniform spread and maximum insect control. Sometimes the diluent is supplied in the formulation itself (e.g. dust formulations), while in other cases, the pesticide is compounded with smaller amounts of inert ingredients and dispersing agents to yield a formulation which can be diluted further with water immediately prior to application. The agriculturalist can handle highly toxic pesticides much more safely after formulation but he should never ignore the inherent danger.

Certain pesticides are prone to rapid de-activation through vaporization or leaching. Various formulations have been designed to give "slow release" of the toxicant, thus prolonging its effective life. These formulations are either simple granules or more elaborate particles, the most recent achievement being the encapsulation of pesticides in extremely small beads with plastic coatings.

TYPES OF FORMULATIONS

SOLID FORMULATIONS

1. Dusts

Dusts comprise a finely divided solid pesticide or a liquid pesticide absorbed in a finely divided inert solid, both of which are intimately mixed with a solid inert diluent. The concentration of active ingredients in the finished product is usually one or two percent although lower or higher concentrations are also used. The dusts are supplied by a mechanical blower, or less commonly, by hand.

2. Wettable powders

A wettable powder includes the toxicant, an inert inorganic diluent, as well as wetting and dispersing agents. Active pesticide levels normally range from 25% to 80% of the formulation. The formulation is ground to a very fine powder which is mixed with water just before use to produce a suspension of extremely small solid particles suitable for spraying. The ability of the wettable powder to remain suspended for a reasonable time between its dilution and application is dependent upon the fineness of the particles as well as the presence of dispersing agents.

3. Granules

In the case of the granules, the inert diluent is composed of particles of absorbent solid. The pesticide or, more commonly, a solution thereof, is impregnated into the absorbent granular particle. Pesticide concentrations may range from 5% to 20%, a few granules having concentrations beyond this range. Particles between 4 mesh (4460 microns) and 80 mesh (177 microns) are considered granular particles for formulation purposes. The most common particles are clay granules, although ground nutshells or corn-cobs are sometimes used.

LIQUID FORMULATION

1. Solutions

The simplest liquid formulations are pesticide solutions in hydrocarbon oil or water. They may be applied directly or diluted further prior to application. These formulations do not usually contain surface active agents, since the pesticides used are adequately soluble. The use of oil solutions for direct application to plants is of limited value because many oils are phytotoxic. Many herbicides are water soluble as akali metal or alkyl amine salts. The solution may contain up to 4lb/gallon herbicide and is simply diluted with water prior to application.

2. Emulsifiable concentrates

This formulation is often the most economical of the liquid pesticide formulations. The emulsifiable concentrates are designed to permit final dilution of the formulation with water. Most pesticides are water insoluble, but soluble in such organic solvents as kerosene and similar aliphatic solvents. Many more are soluble in aromatic solvents such as xylene and

heavy aromatic naphta. These inexpensive organic solvents are used where applicable and oil soluble emulsifying agents are added to the hydrocarbon pesticide solution to form an emulsion.

3. Dispersible concentrates

Formulations with water miscible organic solvents are rare and only used for inadequately soluble pesticides. Suspending agents are added to ensure that upon dilution with water the pesticide remains suspended until application.

4. Miscellaneous liquid formulations

Liquid formulations known as "flowable concentrates" can be made in which an insoluble pesticide upon admixture with water is ground with dispersing agents to produce a fine dispersion.

FORMULATIONS OF VALUE TO DEVELOPING COUNTRIES

Any of the formulations described above can easily be made in a developing country. However, each country must decide whether it really needs to produce pesticide formulations and which types.

Careful analysis should be made of the economic benefits of producing formulations locally. The analysis must review the types and quantities of the pesticides currently used and the country's future requirements. If a country's pesticide requirements do not justify local formulation, the country concerned could consider building a joint plant with their neighbours.

A survey should also be made of the formulations used in both the agricultural and public health sector. As agricultural practices change very slowly, good reasons would have to be found for advocating a change from dusts to liquids.

A review should also be made of locally available raw materials which provide the greatest incentive for the plant. As emulsifying agents and dispersants are so specific in their effectiveness, careful tests should be made before a local material is substituted for an imported product. It should also be remembered that the availability of domestic labour alone does not justify local formulation.

PREPARATION OF PESTICIDE FORMULATIONS

METHODS AND MATERIALS

1. LIQUID FORMULATIONS

a. Solutions

Pesticide solutions are very simple to produce. The solvents used are water and more frequently kerosene or other petroleum fractions. The ingredients are normally compounded by weight ratios so platform scales, or a weigh tank at the most, are required. The pesticides and solvent are transferred from the weigh tank to a mixing vessel, where, in some cases, the mixtures are heated.

In some cases this simple preparation may be part of the operation for preparing an emulsifiable concentrate, in others the solution may be impregnated in a solid carrier or support (see sections 2 and 3).

b. Emulsifiable concentrates

When preparing emulsifiable concentrates, the pesticide solution is prepared as above and emulsifiers are added for simultaneous dissolution. Kerosene and more frequently aromatic hydro-carbons, such as xylene and heavy aromatic naphtha, are used as solvents, the choice of emulsifiers and their concentrations being critical. Like simple solutions, emulsifiable concentrates can be employed directly or diluted prior to application.

At the simplest production level, the relatively safe, non-volatile ingredients can be poured by hand from shipping containers. However, when large amounts are involved, storage tanks, bins and mechanical conveyors are necessary.

Herbicides should never be formulated in the same equipment as insecticides or other pesticides, as traces thereof could contaminate insecticides to such a degree that crops would be seriously damaged. However, insecticides of all kinds can be mixed in the same equipment as long as it is adequately cleaned between mixes.

2. DUSTS AND WETTABLE POWDERS

a. Dusts

The dusts are the simplest solid formulations, comprising one or two percent (occasionally less, and sometimes up to 5%) of toxicant in intimate admixture with an inert ingredient, such as talc, diatomaceous earth, pumice, attapulgite, kaolin, silica, etc.

The inert material and the friable solid insecticide are ground further to a "dust base" which is subsequently diluted with additional dust in the ribbon-blender to yield the final formulation. Particle sizes smaller than 325 mesh (44 microns) are not required in dusts. Where a liquid pesticide is formulated as a dust, highly sorbent clay or a similar ingredient may be used to absorb the liquid to produce a concentrate containing 10% pesticide which can be subsequently mixed with a much larger quantity of a less costly, non-sorbent inert dust.

The preparation of dusts is much more hazardous than the formulation of liquid pesticides. Proper ventilation and the use of exhaust hoods is essential. Certain "inert" ingredients, notably clays, contain catalytically active moieties which can cause rapid deterioration, necessitating deactivation through such additives as diethylene glycol, urea and hexamethylene-tetramine. This problem is present in all solid formulations, but is particularly acute in dusts with high inert pesticide ratio. Heat sensitive pesticides cannot be ground with the inert diluent because heat builds up during grinding they are better suited to spray blending techniques.

b. Wettable powders

Wettable powders differ from dusts in the following manner: (1) they normally contain a much higher percentage of active ingredient (50-80%); (2) they also contain wetting agents and dispersants; (3) they are normally ground very much more finely than dusts, with particle sizes as low as 2 microns.

Wettable powder formulations are almost indispensable for pesticides which are insoluble in common inexpensive solvents.

In the initial stages, wettable powders and "dust bases" are made in the same manner, the difference being that the wetting agents are incorporated during the initial grind or in the solution used to impregnate the pre-ground dust. The dust containing pesticide, inerts, wetting agent and dispersing agent is then ground to the desired particle size.

3. GRANULAR FORMULATIONS

The base for granular formulations is the preformed granule which has sufficient porosity to absorb an adequate amount of the pesticide and yet retain its free-flowing characteristics. The particle must also be hard enough to withstand attrition as fines would give rise to inaccurate application rates and in effect represent a loss of pesticide by over-dosage in certain locations.

Although supports of organic origin are used, attapulgite clay, montmorillonite and other sorptive minerals offer the best properties. The clay is first dried under carefully controled conditions, then calcined to reduce it to the desired water content without loss of porosity, then ground and sized. Preparation of the clay granules is a major manufacturing operation, hence the mere presence of clay in a developing country does not guarantee a source of raw material for fomulation of granules.

When using clays particular attention must be giben to the deactivation of catalytically active sites which could otherwise cause many pesticides to decompose. The most common deactivators are poly-glyclos, urea or hexamethylene tetramine which are sprayed onto the granules in a rotary mixer.

The pesticides are applied onto the granules in the same manner, solids with a low melting point, being melted with just enough solvent to lower viscosity, whereas solutions are used for solids with high melting points. Mild agitation of the product may be necessary after ageing and before bagging to break up any lumps.

FORMULATION PLANTS: TYPES OF EQUIPMENT AND COSTS

It can be surmised from the preceeding discussion of formulation methods and materials that there is a wide variety of plant equipment and layouts. If only one or two types of formulations are to be made, equipment requirements are correspondingly modest. Furthermore, if only limited amounts of less toxic pesticides are to be formulated, safety devices can be kept simple and manual labour rather than mechnical equipment used thus substantially reducing investment costs.

A formulation plant can cost between a few thousand and several hundred thousand dollars depending on the production capacity and versatility. For instance, in the simplest possible installation, producing chlordane emulsifiable concentrate the mixing kettle could be a 50 gallon drum (preferably of stainless steel) mounted on a platform scale set under a shelter which in a warm climate need have no walls to provide adequate natural ventilation. Kerosene, the preferred solvent, could be simply poured into the drum, the scale indicating the amount added, whereafter the chlordane could be poured into the same drum, and the scales used to show the amount added. Even the addition of a small manually operated pump to facilitate charging would be relatively inexpensive. Emulsifying agents might be weighed on a smaller platform scale and poured into the drum containing the kerosene and pesticide. Probably an electircally driven propeller type stirrer would be used to mix the batch, although a hand paddle could be used. Transferring the finished formulation to small cans or drums for storage would probably require a small hand operated pump, again using a platform scale to measure the amount transferred. Assuming the whole operation to take an hour (a conservative estimate, especially if two mixing drums and two large scales are available), the capacity of such a plant in an eight-hour day would be about one ton of formulated chlordane.

It is not suggested that a plant of this kind would meet anything but the simplest requirements as it lacks versatility. It would be positively lethal if used for some of the more toxic pesticides. It simply represents the lower financial limits for a formulation plant where the requirements are extremely simple and adequate manual labour is available. All the facilities needed for a simple plant would cost less than fifty thousand dollars, whereas a large scale-integrated plant may cost several hundred thousands of dollars.

LIQUID FORMULATION CENTRE

A formulation plant usually needs a liquid formulation centre to prepare liquid pesticides and emulsifiable concentrates for various uses. It is usually a very simple section of the plant with storage facilities (tanks or drums) whence the various liquids are pumped to solution kettles. Lines through which molten pesticides are transferred are steam traced. Platform scales and weigh tanks (or flow meters) are used to weigh ingredients and liquids respectively, fillers being provided both before and after the mixing kettle. Pesticide melting and mixing kettles are normally of stainless steel as some pesticides, such as endrin, are highly sensitive to traces or iron salts. To ensure mixing efficiency, the formulation is transferred from the mixing tank to holding tanks once the solution is completed and thence the drumming and canning position. To provide formulation flexibility, the mixing kettle should be steam jacketed; however, for certain solutions heating is unnecessary or even hazardous since pesticides, such as methyl parathion formulations, readily decompose at high temperatures.

Good ventilation is essential in a liquid formulation centre to remove hydrocarbon and toxic pesticide vapours. Where extremely toxic pesticides are to be formulated, the mixing area should be enclosed and provided with a forced draught ventilation system and exhaust hoods over the equipment (e.g., mixing kettle).

SOLID FORMULATION CENTRES

A solid formulation centre is usually linked to a liquid formulation center. In plants producing only granular formulations a rudimentary liquid plant must be provided to supply liquid deactivators and liquid pesticides for the solid granular carriers. Even with low melting toxicants, some solvent is used to be sure of good distribution during the impregnation stage. Where heated solutions are used, all lines transferring pesticide from the melting to the mixing kettle must be steam-traced.

The heart of the granular plant is the mixer in which the support granules are continuously tumbled and revolved while being sprayed with pesticide solution. In general, it resembles a concrete mixer; in fact, concrete mixers have been suitably modified, fitted with spray manifolds and used for preparation of granular formulations. The mixing and tumbling action must ensure continuous exposure of new granules and their surfaces to the spray, but it must no be so severe as to cause production of fines through attrition. With some granulars a post-impregnation, ageing period of several days is required to give a completely dry granule, whereafter a mild tumbling is employed once again to break up any agglomerates before final packaging.

The granules are gravity fed to the mixer and the bag-filling site from elevated hoppers, which are loaded by mechanical or manual means to avoid attrition due to pneumatic conveyors.

Solid formulation centres for dust and wettable powders use common pieces of equipment. Assuming that a liquid centre is available to handle liquid pesticides, deactivators and prepare other solutions, the grinding mills and dry blenders are the heart of the dust and wettable powder sections. Mills are the most expensive parts of the plant, the cheapest being hammer mills, which are used to prepare a dust base by grinding together pesticides with relatively high melting points and inert ingredients. It may also be used to pre-grind inert materials where the pesticide is to be subsequently added as a liquid or solution, or for the preliminary grind of a wettable powder.

If the inert diluent is already fine enough (44 to 74 microns) milling may not even be necessary. Assuming adequate sorbency, the formulation is carried out in a ribbon blender by simply spraying a deactivator, if required, and a pesticide solution onto the carrier under continuous agitation. If a friable solid pesticide is used, it is simply milled with the diluent in the hammer mill.

When pesticides are ground with diluents in the hammer mill, considerable heat builds up. With low melting pesticides this may block the grates or screen and lead to low throughput rates, hence a side-roll mill where the operating temperature can be adjusted may prove more adequate. It should be pointed out that for heat sensitive materials such as methyl parathion, the carriers should be preground and simply blended with the pesticide.

Air mills (fluid energy mills) are best for wettable powders on account of the particle size requirements (2 microns) where the particles are ground by attrition in a high-speed air stream. Preliminary griding on one of the less expensive mills (mentioned above) is certainly desirable from an economic standpoint. The wettable powders differ in one other respect from the dusts, they contain incorporated wetting and dispersing agents (and sometimes other additives).

Ventilation and dust collection systems are an integral part of the solid formulation centre, the dusts and wettable powders being transported within the plant by bucket elevators, screw conveyors or pneumatic systems. Despite the use of cyclone separators on conveyors and other equipment, the amount of dust escaping into the operating area makes an efficient ventilation system essential for safety reasons; the more toxic pesticides, the more rigorous the control.

In an integrated plan, a solid formulation unit is estimated to cost 30-40% of the total plant cost, not including the building, ventilation facilities, warehouse or auxiliaries. The major portion of the cost lies in dust and wettable powder formulation facilities, the equipment for granulars being relatively cheap once the liquid plant is available. Including a proportional share of the necessary auxiliary equipment, the cost of solid formulation equipment would be to the order of 60% of the cost of an integrated plant.

Generalizations such as those in this section always incur the risk of creating the wrong impression and numerous important details have had to be omitted. The cost estimates must be gross approximations for want of more specific data. Formulation plants often include previously used equipment which immediately reduce costs, and manual labour would almost certainly replace conveyors, lift trucks, etc., in the developing countries.

QUALITY CONTROL, SAFETY, WASTE DISPOSAL

Pesticides are normally used at rates based on a specific number of pounds of active toxicant per acre (or kilograms per hectare). Amounts used are critical, as they provide adequate pest control without waste; and it is essential that a 25% wettable powder, for example, always contains 25% toxicant.

Consequently, laboratory facilities are needed, inter-alia, to carry out periodic checks on active ingredient contents and post-storage toxicity. For wettable powders and emulsifiable concentrates, periodic dispersion and water suspension tests are performed to guarantee uniform product quality.

Operational safety in a formulation plant entails something more than ventilation and dust control. The danger of inhalation or of direct contact with certain highly toxic pesticides makes the provision of protective clothing a necessity. Unintentional spillage of dangerous chemicals can create decontamination problems, hence floors of areas where liquids are handled must have impervious surfacing and no drains to prevent polluting the water supply. Prior to their disposal, pesticide wastes must be detoxified while exhaust air from ventilation systems should be scrubbed to avoid damage to crops in surrounding areas.

Waste disposal entails proper waste management procedures such as re-cycleing of dusts collected in the conveyor system. Most phosphates and carbamates can be rendered relatively innocuous by hydrolysis, other waste can be burned. Metal drums should be decontaminated and old paper sacks should be burnt, consequently the provision of adequate incineration and disposal facilities is an important factor when planning a pesticide formulation plant.

ANNEX B

Category 1

D R A F T

Request from the Government of

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for

Special Industrial Services

Post Title:	Pesticide Formulation and Marketing Expert
Duration:	Two to six months
Date Required:	As soon as possible
Duty Station:	----------
Purpose of the Project:	The Government is interested in improving and buttressing agricultural productivity by regulating the supply, commerce and efficient use of pesticides for preserving crops and harvested products.
Duties:	The expert shall assist the Government in introducing improvements in the following areas of the pesticide industry and marketing:

a. Collect information on the potential needs of pesticide supplies of the country based on a cost and benefit analysis and prepare a forecast report for the next decade. (FAO is available for consultation and assistance in this phase of the development).

b. Adapt or establish quality standards for all imported pesticides, (in co-operation with FAO).

c. Establish, if possible, a control laboratory which shall examine the quality of imported pesticides and check pesticide residues in export crops and food shipments. If unpracticable, owing to lack of facilities and trained personnel, certification by importers shall be required and the examination of such certificates and pesticide residues in exported food products should be contracted with a third country institution. Establishment of a regional control laboratory may offer an alternate solution.

d. Provide training opportunities in developed countries to technical personnel required for handling the above quality control tasks. Training of operators and applicators involved in the final application of pesticides can be provided locally with the assistance of FAO and UNIDO.

e. Organize a bulk purchase scheme for important pesticides and thereby obtain better financial terms

and develop packaging centres and an efficient distribution system, either by expanding and regulating existing channels or by creating new ones.

f. Examine the pricing structure and suggest suitable legislation to restrict unjustified profit margins and other unfair trade practices in order to encourage the use of pesticides. This can be done by the Ministry of Agriculture with the assistance of UNIDO advisors.

g. Consider organized cropping and production of naturally occuring botanical pesticides, such as rotenon (derris) sabadilla, ryania, quassia, pyrethrins, nicotine.

h. Draft a legal code covering quality control of imports. price control and credit policies to encourage use of pesticides and regulations of trade with toxic pesticides, including proper warnings, packaging, and distribution of pesticides and the training of key personnel involved in the control, distribution and commerce of pesticides. This code should also provide for commencement of local manufacture and the proper development and management thereof.

Qualifications: Chemical (industrial) engineer or chemist with experience in the formulation and marketing of pesticides.

Language: English (French or Spanish)

Background Information: Agricultural production is a mainstay of the country's economy; production methods, however, are mostly traditional and subsistence oriented. The technical infrastructure - both in agriculture and industry - is very weak or non-existent. All pesticides are presently imported and the size of the market does not seem to justify the establishment of local pesticide industries. The sale of pesticides reaching the country is in the hands of a few distributors and small shop-keepers who know little about the activity, toxicity, shelf-life and proper application of any of the pesticides they handle. In order to increase agricultural production and render it market-oriented, it is necessary to introduce efficient regulations for the supply and use of pesticides for the benefit of the farmers.

ANNEX (
(ategory 2

D R A F T

Request from the Government of

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for

Special Industrial Services

Post Title:	Pesticide Formulation Expert
Duration:	One to two years
Date Required:	As soon as possible
Duty Station:	----------
Purpose of the Project:	The Government is concerned about the low level of agricultural productivity and especially about the inadequate and ineffective use of pesticides for the protection of crops and harvested products. The Government would like to establish a local pesticide formulation plant to reduce the cost of the products to the farmers and make full use of local resources (raw materials) and labour force.
Duties:	The expert shall assist the Government in making improvements in the following areas of the pesticide industry and marketing:

a. Market surveys to establish the demand for widely used pesticides and assess future market growth.

b. Adoption or establishment of quality standards for all pesticides (in co-operation with FAO).

c. Establishment of a control laboratory to analyse all imported and locally produced pesticides and to check pesticide residues in crops for export.

d. Training opportunities in industrialized countries for technical personnel to staff control laboratory or participate in other phases of pesticide commerce (formulation, marketing, etc.)

e. Correction of pricing structure by means of suitable legislation to control unfair practices and to establish credit policies to further the use of pesticides.

f. Feasibility study concerning the establishment of a local formulation plant, including availability of local raw materials (diluents, carriers).

g. Planning and erection of pesticide formulation plants including ~~including~~ preparation of tenders and evaluation of bids for the selction of construction firms.

h. Assistance in attracting foreign capital and know-how for national pesticide projects.

Qualifications: Chemical engineer or chemist with extensive experience in formulating and marketing pesticides.

Language: English (French or Spanish)

Background Information: Agriculture accounts for the largest single contribution of the GNP, but at present, its potential is under-exploited. Losses caused by insects and other pests represent a serious obstacle in getting higher yields. Since agricultural exports should earn the foreign exchange much required for the industrialization of the country, such losses have an adverse effect on national economic development. Currently, all pesticides are imported as formulated end-products at considerably high cost. The high cost also stays in the way of the proper and effective use of pesticides. The efficient utilisation of the country's agricultural potential would require improved farm management methods and higher and better physical production inputs, such as pesticides. Establishment of a local pesticide formulation plant, using domestic raw materials (diluents, carriers, solvent, etc.) and labour force could result in a substantial reduction in the cost of products to the user. Suitable credit policy measures enabling the farmers to buy pesticides at crop-terms and adequate technical training for personnel involved in the production, distribution, marketing and control of pesticides are also lacking.

ANNEX D

Category 3

DRAFT

Request from the Government of _____

for

Special Industrial Services

Post Title: Pesticide Production and Quality Control Expert (Consultant)

Duration: From two months to two years

Date Required: As soon as possible

Duty Station: _____

Purpose of the Project: The Government intends to increase and diversify the formulation and production of selected pesticides which are presently imported and used in large quantities. By establishing such industries, substantial foreign currency savings could be achieved, possibly amplified by exports to neighbouring countries.

Duties: The expert (consultant) shall assist the Government in its effort to develop the pesticide industry and marketing in the following areas:

a. Market surveys to increase or redefine local manufacture and establish if local markets (i.e., regional markets) have grown sufficiently to justify more diversified production.

b. Efficiency studies to pinpoint technical or organisational weaknesses in existing formulation plants the elimination of which would increase the output of product line.

c. Feasibility studies for establishing production units to manufacture basic active ingredients for technical pesticides. A multi-purpose plant producing different ingredients in a series of production runs may be preferable to a separate plant for each product.

d. Planning and erection of plants manufacturing one or more speciality pesticides of proven feasibility, and assist in securing know-how from firms and organizations in industrialized countries.

e. Assess the industry's export potential.

f. Training of technical personnel for staffing new production plants as well as quality control laboratories.

g. Organizing country-wide control of pesticide residues in food exports.

h. Establish research and development laboratories to study the problem of new pesticide formulations fit for local conditions and to exploit local resources to a maximum possible degree.

Qualifications: Chemical engineer or chemist with broad experience in pesticide production and marketing.

Language: Spanish (English acceptable)

Background Information: The country has made remarkable progress in industrial development during recent years. Urban areas are flourishing by rural development, particularly the use of chemicals and machines in the agriculture, is lagging because of the high cost of the required products (fertilizers, pesticides) most of which have to be imported from distant industrialized countries. In terms of volume, agriculture is still the most important sector of the economy; its modernization is therefore of great importance. Market information indicates local production of a number of pesticides is feasible and could result in substantial foreign currency saving and bring greater benefit to the farmers. The country's infrastructure and raw material sources are adequate for pesticide manufacture. Nevertheless, certain existing operations in the field of pesticides are not working with high efficiency due to organisational weaknesses and lack of managerial skill.

ANNEX E

Category 4

D R A F T

Request from the Government of

for

Special Industrial Services

Post Title: Pesticide Production Expert (or consulting firm)

Duration: Six months to one year

Date Required: 1973/74

Duty Station:

Purpose of the Project: A pesticide production expert (or consulting firm) shall provide assistance to the Government in establishing whether local production of selected organic phosphorus insecticides (or organic herbicides, organic fungicides, etc.) is feasible in view of potential markets, availability of production know-how, local raw materials and an adequate industrial base.

Duties: The expert (consulting firm) shall assist the Government in its effort to improve the efficiency of and diversify the pesticide industry in the following aspects:

a. Increase the size and scope of research effort with a view to:

(1) improving technologies to increase competitiveness;

(2) developing modified or original pesticides suited to the country's needs and raw material resources.

b. Develop or expand export business, involving the attainment of international quality standards and a thorough survey of potential export markets.

c. Regroup or rationalize manufacturing units to achieve maximum efficiency and reduced production costs.

d. Develop a multi-purpose production or pilot plant for the production of experimental or small volume products.

e. Establish technical co-operation with foreign and international organizations in order to assure access to up-to-date technical and scientific information, expanding product lines as justified by domestic requirements or export possibilities.

Qualifications: Chemical engineer or chemist (consulting firm) with broad experience in the production of pesticides.

Language: French (English acceptable)

Background Information: The country has achieved remarkable progress in raising the efficiency of agricultural production by adopting modern agricultural production and extending adequate and balanced applications of fertilizers and pesticides to a large portion of the total cultivated area. Demand for pesticides is already high and continues to grow. Most of the pesticides are presently supplied by foreign producers imposing a heavy burden on the national economy and an undesirable limitation on the proper use of pesticides, particularly in small farms. The country has a well-developed organic chemical industry, but not specialized in pesticide production. Many of the raw materials required for the production of basic pesticides are locally available. With growing domestic markets and export possiblities to neighbouring developing countries, the country seems to have excellent potential for the local production of selected pesticides.

ANNEX F

WHAT IS UNIDO?

The United Nations Industrial Development Organization (UNIDO) was established in 1967 by the General Assembly of the United Nations, to promote and accelerate the industrialization of the developing countries. The Assembly also gave UNIDO the central role in co-ordinating all the activities of the United Nations system in the field of industrial development.

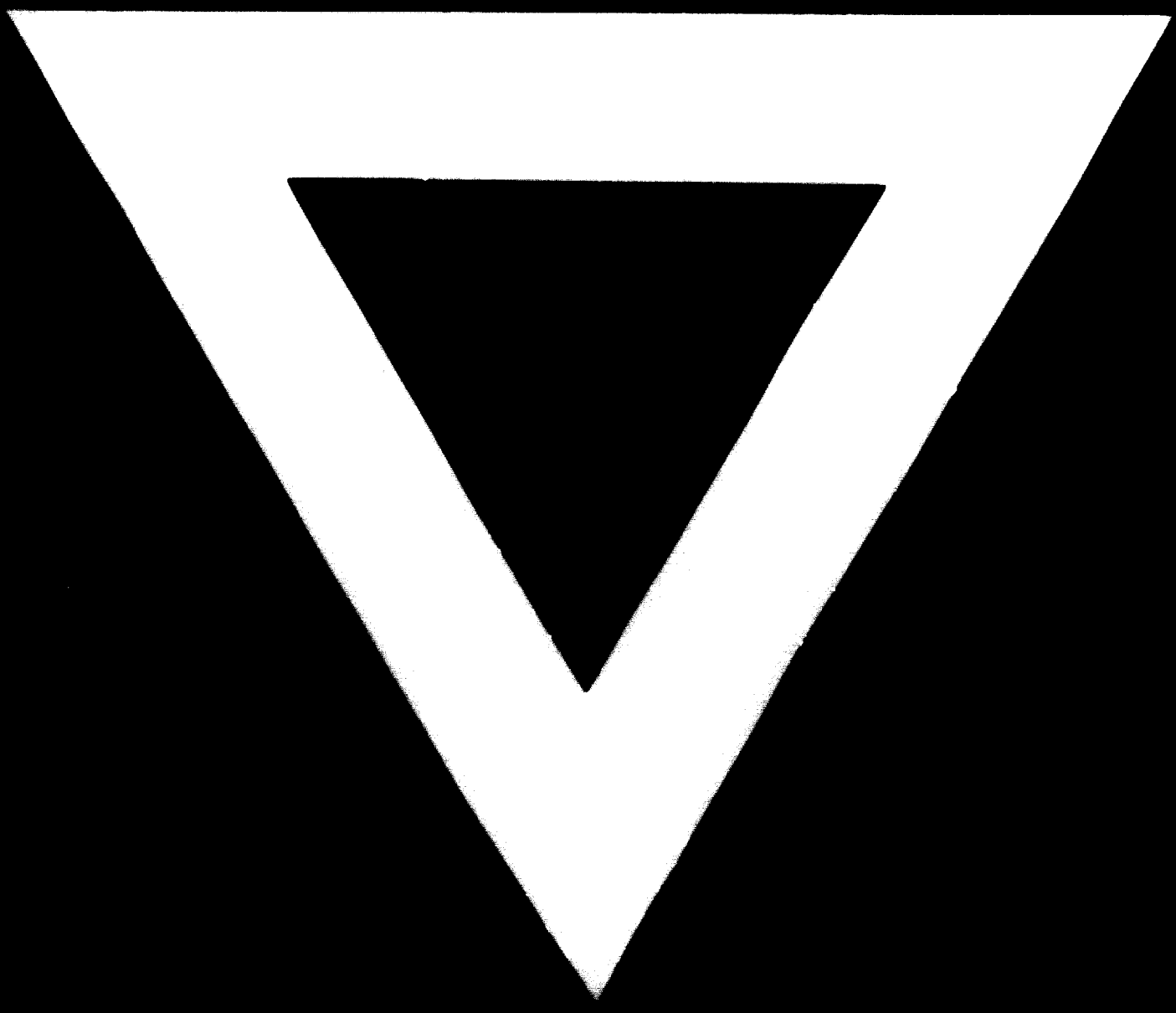
In fulfilling its mandate, UNIDO undertakes two basic types of activity: operational activities, involving direct assistance to developing countries, and related supporting activities, which include action-oriented studies and research. Under its operational activities, UNIDO can make available to developing countries a wide range of services. It can help in:

- the establishment, operation and management of industrial enterprises;
- the preparation of industrial development plans;
- the training of staff;
- the solution of problems related to the industrial use of natural resources and raw materials;
- the building of effective national organizations to administer industrial services.

Member governments are assisted, at their request, to identify opportunities for investment, set up research and training institutes, operate industrial design centres or launch pilot or demonstration plants. Such long-term pre-investment projects involve the provision of experts, consultants and equipment, as well as fellowships for training abroad. In addition, UNIDO provides experts for periods ranging from a few weeks to a year or more, to help solve urgent industrial problems or advise on specific aspects of the industrial process.

In support of its field activities, UNIDO convenes international seminars, workshops and expert group meetings to permit an exchange of views on various issues and problems of industrial development. It also organises in-plant training programmes, at which industrial engineers and technicians from developing countries are given practical training in factories in the industrialized countries.

Expenses for the administrative and research activities of UNIDO are borne by the regular budget of the United Nations. For its operational activities UNIDO draws on part of the regular budget of the United Nations as well as on voluntary contributions from member governments, principally through the United Nations Development Programme (UNDP).



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