

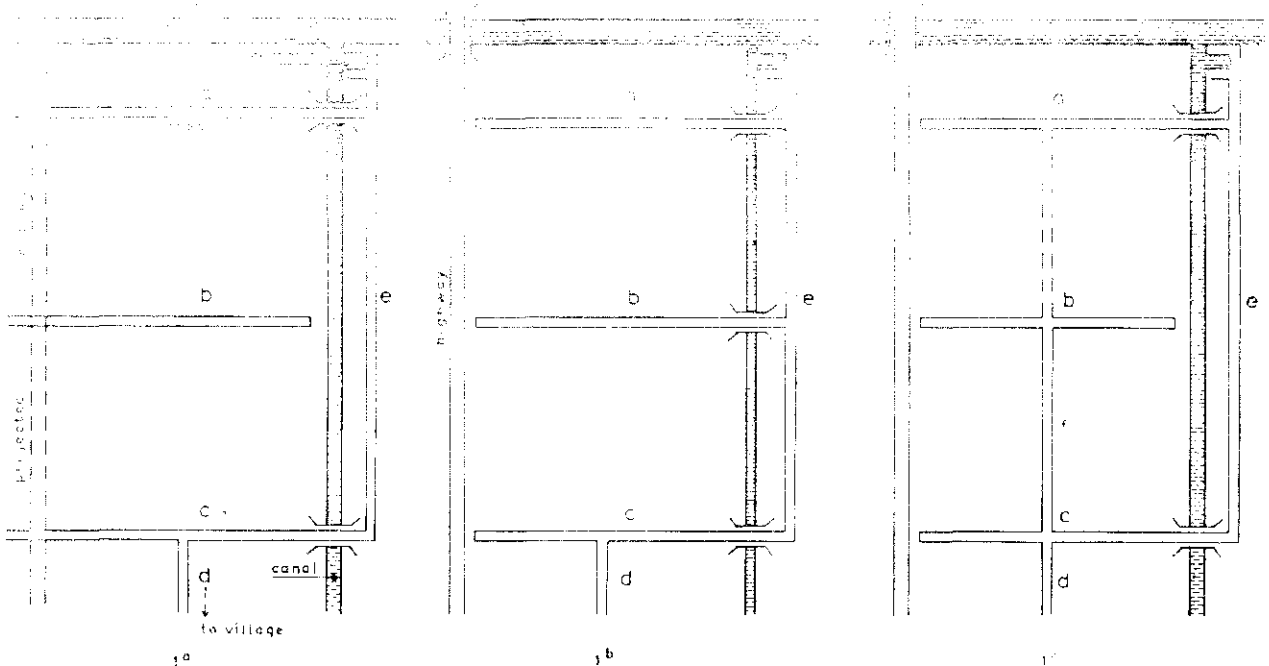
OPERATIONAL RESEARCH

in land consolidation projects



Shifting subsoil into ditches.

Road plans for an area isolated by the construction of a highway; 1a, Existing situation; 1b, Road b connected with the village by a new bridge and road e; 1c, Road b connected with the village by a new road f.



When running an organization, irrespective whether it concerns a farm, a factory or an army, every moment decisions have to be taken regarding the procedure to be followed to achieve the end in view. Generally the aim is to attain the best possible results with the minimum of sacrifice. This means in the case of an industrial or agricultural concern to obtain the largest possible profit that can be made with the available means and for an army the greatest likelihood of victory with the smallest possible losses in men and material.

When taking essential decisions, action is often taken more or less intuitively on the strength of qualitative considerations or by comparison of a limited number of alternative possibilities, of which the pros and cons have been established, quantitatively or otherwise. When the alternatives are indeed quantitatively compared in a scientific manner, one can speak of operational research. Since the Second World War methods have been evolved in which the available means are determined quantitatively and then mathematically processed in such a way that step by step better solutions are found, until ultimately the optimum solution to the problem is obtained. One speaks in this connection of linear programming if in the mathematical problem all the important relations are linear, i.e. that for example the production of two units requires twice as much material as the production of one unit.

In the organizing of rural areas by reallocation of the land, it is also constantly necessary to take decisions involving a large number of factors, both on the policy and the execution level. The projects that make up such plans include those on water management, construction of roads for agricultural purposes, division of the area into parcels of a rational size and shape, location and layout of farm buildings, landscape design, etc.

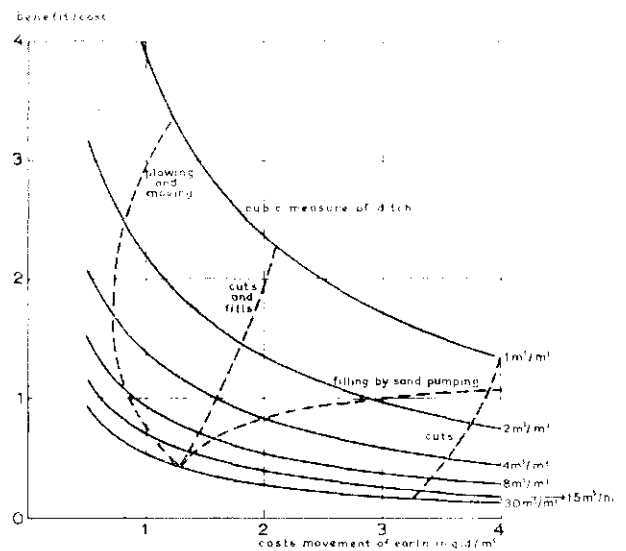
Before these plans are drawn up, it must have been decided which type and what size of farm establishment must be regarded as the most suitable, how much the execution of the plan may cost, and so on. These decisions will usually be taken after careful consultations of managers with technicians. At policy level, the question will have to be answered whether the government must provide funds for the land consolidation projects or whether the available funds should be used for other government tasks.

Once it has been decided that land consolidation is a government task — as is the case in The Netherlands — decisions must then be taken in regard to the nature of the projects to be carried out and the areas which should be given priority in the execution.

Finally, it must be decided who should execute the project and to what extent the interested parties should contribute financially to the realization of the project.

All these decisions, which precede the actual project decisions, have — apart from the agricultural and economic aspects — also a clearly social character. It may be preferred, for example, to invest the available funds in areas where such investments will give the highest possible revenue, but it is also possible to take as a criterion the present low income level and the expected rise in prosperity, and on the strength of this to accept a lower revenue of the investment.

Hence, the primary decision concerns the criteria on which the evaluation of the projects will be based. These so-called normative decisions, which also play an important part in the planning technique discussed below, determine to a very large



Influence of soil-shifting costs on the benefit/cost ratio for filling ditches.

extent the ultimate choice. In effect such decisions will usually be taken in the political sphere.

Once the decisions at policy level have been taken, the time has come to draw up plans. The application of operational research when making land consolidation plans in The Netherlands will be illustrated with a few examples.

Planning technique

No land consolidation project can be carried out unless first the aim and the nature of the work have been defined and the costs estimated. The setting up of plans for such projects, asks for a certain planning technique.

The more comprehensive and the more complicated a project is, the greater the number of factors that are essential to the plan. There is, of course, a close interdependence of these factors, on which the decisions must be based.

The planning technique in the sphere of land consolidation on behalf of a complicated project such as present-day reallocation of land meets with problems that can only be solved by quantitatively comparing, as far as possible, a number of appropriate alternatives.

To be able to draw up sound alternative plans and to reduce the risk of the best solutions being overlooked, the problems in question and the possible solutions must be properly analysed first. The risk of missing the best solution makes it imperative that more or less major decisions must not be taken in too early a stage or at too low a level.

The decisions to be taken with respect to reallocation plans are often difficult, because, apart from agricultural interests, there are also other interests involved, such as housing, transport, recreation and scientific research. In most cases it will hardly be possible to express all the important aspects quantitatively in such a way that they can be weighed against each other. Consequently a more or less arbitrary choice will be practically unavoidable.

For example, when shifting farmhouses from a village to more outlying locations, the resulting agricultural advantages of living near the land to be worked must not only be weighed against the extra cost of erecting new farm-buildings at a

time when the old buildings are still usable as such, but allowance must also be made for secondary advantages and disadvantages.

On the one hand, better reshaping possibilities of the village and the advantages of living on a modern farm, on the other hand the greater distance from the new farm to the school, the church and the general service facilities. Such social values cannot be expressed in terms of money, but may be very important.

In such cases also, however, the making of alternative plans can be highly clarifying.

Alternative plans

An important condition for the proper organization of an area is, therefore, that the choice of the definitive project is based on a comparison of appropriate alternatives, either for the plan as a whole or for suitable parts thereof. Almost as important is that this comparison must be made as far as possible on a quantitative basis.

This not only furnishes an insight into the costs and assets of a given project, but at the same time one is compelled to consider what gaps there still are in the available knowledge. The examples discussed below are based on benefit/cost calculations, although on some points other factors have also been taken into account. In making a choice from a number of alternative plans, important aspects are, besides the benefit/cost ratio, the investment level and the flexibility of the plans.

Agrarian development

In fig. 1 a highly simplified example is given of a number of alternative development plans for an area in which the building of a highway results in three of the four existing access roads being closed off (fig. 1a). In making in this case a choice between the building of over or underpasses, if necessary in combination with parallel roads, and the incorporation of this area in a reallocation scheme, the second solution is to be preferred on economic grounds.

Pumping soil for filling ditches.



The reallocation scheme renders the closed-off access roads superfluous, because the parcels of land can be allotted to users living near the remaining access road *d*. An added advantage is that by concentration of the holdings the number of parcels per user can be substantially reduced.

In the case of reallocation it is of course essential that the cut-off road *b*, which terminates in a dead end on the east side near the canal, is once more connected with the existing road network. This connection can be achieved by building a bridge over the canal (fig. 1b) or by constructing a new road *f* — as a continuation of road *d* — while this new road can, if necessary, be extended right up to road *a* (fig. 1c). The advantage of the new road *f* is that it makes the distance from the majority of the parcels to the village situated near road *d* shorter, since otherwise a detour over road *e* is necessary. As a result the plan with a new road *f* is, despite the higher costs, more profitable. When taking into account, however, that part of the transport from the parcels is directed towards the harbour, it is found that the profitability of the two plans is practically the same.

If, on the other hand, it is decided to establish new farms along roads *a* and *b*, the cheap road plan of fig. 1b is to be preferred, because in that case the small amount of agricultural traffic between the village and this area will remain so.

To make a correct choice between the various development plans possible, it is necessary to have also a clear insight into the future traffic conditions in the area.

Filling of ditches

A different problem is encountered in polder areas with a large number of parcels and with many ditches for drainage purposes. In the reallocation scheme the replacement of these ditches by a system of drain-pipes must be considered, since the ditches require a lot of maintenance, often do not ensure proper drainage and sometimes cover a substantial area.

The benefit resulting from the filling of the ditches must, of

course, outweigh the costs involved. The latter are higher, according as the ditches are wider the cost of filling material higher. This is illustrated in fig. 2, which represents the benefit/cost relationship, the volume of the ditches and the cost of soil-shifting. If the ditches in the area concerned have a volume of appr. 2 cu.m per linear metre, the cost of soil-shifting should not be more than 3 Dutch guilders per cu.m under the conditions prevailing in The Netherlands at the moment, to achieve profitable results.

This condition is fulfilled if, for example, the filling material becomes available from the improvement of discharge canals; if the filling material must be specially dug for the purpose the costs will be higher. The filling of ditches with a volume of 4 cu.m or more in a grassland area is generally not economically justified, unless other benefits in addition to those referred to above can be expected.

This is the case, for instance, in those parts of The Netherlands where it is desired to change over from water transport to road transport or if next to each remaining ditch a metalled road is thought to be essential.

Fig. 2 also shows the cost curves for a number of soil-shifting methods, much used in land consolidation technique. For filling large ditches there is, in principle, the choice between soil from the adjacent land moved by means of bulldozers, after the valuable topsoil has been ploughed under, or soil obtained from projects elsewhere in the area, or pumping in soil with the aid of sand dredgers.

The last-mentioned method only enters into consideration for ditches with a volume of more than 10 cu. m per linear metre, while the project should also be sufficiently large. In other cases the basic costs of placing the dredger and connecting the pipe-lines would be excessive from the exploitation point of view.

For ditches of more than 10 cu. m volume, however, the costs of the filling-up methods referred to above are equally high and the choice will therefore be determined by additional factors. The dredging and pumping method will be preferred if at the same time sand is obtained for road-building. If on the other hand the ploughing up of filling material can at the same time be used for an improvement of the profile, e.g. by breaking hard pans or other undesirable layers, it is preferable to fill the ditches by means of bulldozers. The same applies when there is no particular need to retain the topsoil, thus when the costs of ploughing it under first are not involved.

The foregoing illustrates the complications which even a fairly simple problem such as the choice of a soil-shifting method can give.

Size of farms

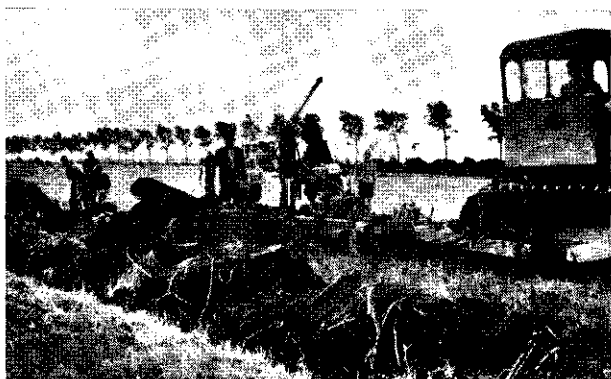
A problem which is very suitable for the application of operational research concerns the most desirable size of farm in areas which are to be redeveloped. This point plays a major role in other decisions to be taken, for example the distance between the roads and the parcel ditches and the number of new farmhouses to be built.

The most important aspects that must be taken into account when determining the optimum size of farms, such as the quality of the soil, the cost of labour, the crop range and the number of cattle, can be determined quantitatively. Such a study made for the new IJsselmeer polders¹⁾ revealed that the economic borderline between a one-man and a two-man farm on sandy clay soil now lies at a size of 21 hectares, while for a farm on clay soil this borderline lies much higher.

Changing the size of farm holdings will give changes in the cropping pattern and the labour requirements. As the size



Placing topsoil on filled ditches.



Deep-ploughing for filling ditches.

of farm becomes larger, cattle-farming is abandoned first and subsequently sugar beets and peas are removed from the crop range in favour of potatoes and wheat, while outside labour must be taken on to an increasing extent.

With higher cost of labour, also a more extensive crop range is to be preferred and the borderline between one-man and two-man farms moves upwards. Furthermore, it was clear that small farms should preferably be established on the light sandy-clay soils and larger farms on heavier soils, which are not so suitable for growing labour-intensive crops.

Conclusion

When drawing up plans for land consolidation projects, it is essential that the criteria on which the evaluation of the alternative plans will be based, are clearly known. A definite line must then be followed from the highest level downward, going gradually into more detail.

Operational research makes it possible to assess the alternative plans to a large extent on the strength of calculation. Often, however, the choice to be made between these plans is made difficult by the widely divergent aspects, of which some cannot be expressed in figures, of the project as a whole.

¹⁾ Louwes, A. J. en J. de Veer. 1960. De economische aspecten van akkerbouwbedrijven van 15 tot 20 ha in de IJsselmeerpolders. Bedrijfseconomische Med. 36. Landbouw-Economisch Instituut, The Hague, pp. 80.