LAND DRAINAGE POLICY IN IRELAND

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Price IR£4.00

(Special Rate for Students IR£2.00)

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ISBN 0 7070 0049 1

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PREFACE

In recent years land drainage policy has received attention on two counts: the adequacy of the financial returns to investment of public funds in drainage has been questioned, and it has been alleged that adverse impacts on the environment also result therefrom.

Two types of drainage - arterial and field - are identified. Arterial drainage involves the artificial widening and deepening of main rivers and important tributaries in order to increase their effectiveness in draining their catchment areas. Field drainage comprises the activities necessary to remove surplus water from fields. The two are interdependent in the sense that in some areas successful field drainage is contingent upon arterial drainage having been undertaken, and the full benefits of arterial drainage can only be captured if the complementary field work is done.

The Office of Public Works (OPW) is the government agency charged with primary responsibility for arterial drainage. It has responded to the above concerns in a positive and constructive manner. Formal and systematic appraisal of the benefits and costs of proposals for arterial drainage has been initiated. One of these analyses has been published. A committee representing the relevant interests provides advice on environmental impact, and the environmental implications of projects are assayed.

We felt that it would be useful at this stage to provide an overview of some of the issues involved in drainage policy, for the following reasons:

(i) Land drainage is regarded as a pivotal element in the EEC - supported efforts to improve productivity in the West, and substantial funds, both from EEC sources and directly from the Irish tax-payer, are to be devoted to this task.

(ii) The Office of Public Works is the only government agency which systematically appraises its investment proposals

and makes its analyses available for public scrutiny. Their first study was initiated in 1970. We felt that, with over a decade of experience in applying this approach, an independent review of its application would be of interest. Our review has implications for the analysis of both expenditure on drainage and for public investment in general.

(iii) Since large areas of the country have already been drained, we felt, a priori, that it was possible that many of the best investment opportunities, in both arterial and field drainage, had already been undertaken; the potential for making inappropriate investments if this were the case would, therefore, be probably greater now than it has been in the past. Furthermore, as the area drained increases, the scarcity value increases of the remaining wetlands and unmodified waterways for fisheries and wildlife habitat.

In this report we try to give the reader a sense of the historical context, followed by an overview and analysis of the issues. In doing so, we draw exclusively on already existing studies and available data; no original field work was undertaken. We focus on the economic efficiency dimension. It is often the case that those lands which are difficult (and therefore expensive) to drain, and which yield relatively low increases in production, will also be of great environmental value. We feel, therefore, that by concentrating drainage investments on those areas where the returns exceed the costs, some of the most environmentally deleterious work will be avoided. We confine our treatment of environmental impact *per se* to a synoptic outline of the primary impacts in this regard and a brief discussion of the manner in which these considerations are dealt with in the decision-making process.

We discovered in the course of this work that land drainage is a sensitive policy area. One individual felt that, by the very fact of undertaking the study, we were choosing snipe over farmers, and were willing to drive people from the land for the sake of a few birds. While this no doubt represents an extreme view, it nevertheless captures the flavour of the sensitivities involved. We want to emphasise that we are not in any sense "against" drainage. To the contrary, we are very much in favour of it when the returns (broadly defined) justify the outlays involved,

and when environmental aspects have been adequately considered. We are "against" drainage investment which costs more than it yields in return. Furthermore, if the land-owner has existing investment opportunities, such as increased stocking, more fertiliser usage, more silage capacity, changed management systems etc., which would yield a greater net return than drainage, then the funds should be directed instead to these. In some - but by no means all - instances it will, of course, be necessary for owners to drain their land before they can apply further inputs to economic advantage.

While our review of Irish drainage policy is perhaps rather cursory, we have, we feel, identified some of the more interesting issues pertaining thereto. We hope that this study will be a helpful contribution to the discussions of drainage in the years ahead.

The report is in five parts: in Section I, past activity in arterial and field drainage is outlined and environmental impacts are discussed. In Section II we present a brief discussion of the economic concepts underlying our approach. In Section III, arterial drainage is analysed in some detail; a review of the legislative and institutional setting is followed by a discussion of cost-benefit analysis as applied by the Office of Public Works. Investment in arterial drainage is then evaluated in this context. In Section IV, a review of progress and expenditure on field drainage is followed by an examination of economically related policy issues. In Section V some recommendations are presented.

We are grateful to Donal Creedon, Larry Dempsey, Pat Doherty and Matt Harley of the Department of Agriculture. They gave us the considerable benefit of their knowledge and experience concerning field drainage. Gabriel Noonan of the Department of Finance provided us with many valuable insights concerning the analysis of arterial drainage. At ESRI Kieran A. Kennedy, Robert O'Connor and Susan Scott gave us very useful written comments. Staff members of the Office of Public Works, notably Frank Fingleton, John Howard and Michael Lynn were generous in the provision of data. We are grateful to Jim Ryan of the National Board for Science and Technology for introducing us to this fascinating topic.

While all of the above helped us considerably in our

deliberations, responsibility for the content and conclusions rests with us alone. We are especially grateful to Noreen Walsh, Maria Swords and other members of the office staff at ESRI who typed the paper with such accuracy and expedition, and to Pat Hopkins who drew the graphs. Maureen Doran-O'Reilly of the library was ever generous with her assistance.

The Office of Public Works stands alone among public agencies in Ireland in its willingness to publish its investment appraisal procedures. We have accepted the invitation implicit in this act and have critically analysed the procedures so described. In doing so we are reviewing techniques of analysis which in many - perhaps almost all - cases are no doubt better than those employed elsewhere in government in Ireland. We salute the members of the Office of Public Works who have had the courage and confidence to subject their work to public scrutiny; this volume is dedicated to them.

1 BACKGROUND

Introduction

Ireland suffers from an extensive drainage problem. The source of the difficulty is not exception rainfall. It is the saucer shape of the countryside with its high maritime rim and flat interior. As a result, the rivers flow slowly through poor channels. Much of the land suffers from periodic or prolonged flood damage. Even at low-flow, the rivers provide poor outfalls that prevent adjoining lands being properly drained. If left unattended, these slow-flowing rivers tend to silt up and the drainage conditions degenerate. So, the need for remedial drainage work is recurrent.

State involvement in arterial drainage has a long history, dating back to famine times. At that time, the work was all done manually, and it employed about forty thousand people at peak. The process has now become highly mechanised with the use of dragline excavators and floating dredgers for excavation, and specialised equipment for drilling and blasting rock. It is all carried out under the central direction of the Office of Public Works (OPW). Fewer than one thousand people are now employed on the programme.

Almost all of the arterial work has consisted of deepening and widening river channels to accommodate existing river flows. The alternative - moderating river flows by diverting rivers or storing in reservoirs - is uncommon. Schemes are designed after the study of long records of water flows and a detailed survey of the catchment. Typically, the channel enlargement aims to give immunity from the three-year flood and to reduce the low-flow water table sufficiently so that satisfactory drainage is achieved of the land areas to be improved. This level of flood immunity means that flooding in the Spring-Autumn growing season will be very rare. The low water table provides sufficient outfall to

enable farmers to fully rehabilitate their land by field drainage.

State involvement in field drainage is of quite recent origin. It takes the form of grant aid. The one experiment in direct work by the state proved unwieldy and was short-lived. The grant is administered by the Department of Agriculture.

Arterial Drainage

In the hundred years from 1840-1940, there were three significant programmes of arterial drainage. Over that period, the state drained about 450 thousand acres, equal to 4 per cent of farm land.[1] Individual schemes were typically quite small, averaging 2,000 acres each. The peak of activity occurred in ten years spanning the famine period, when over half of all this work was carried out. Unfortunately, much of the work done under these programmes was allowed to fall back into chronic disrepair for lack of maintenance.

An Act passed in 1945 gave arterial drainage new impetus. This Act removed several obstacles which were impeding the drainage programme. The most notable change was the shift from tackling drainage problems in a piecemeal fashion to draining entire catchments at a time.

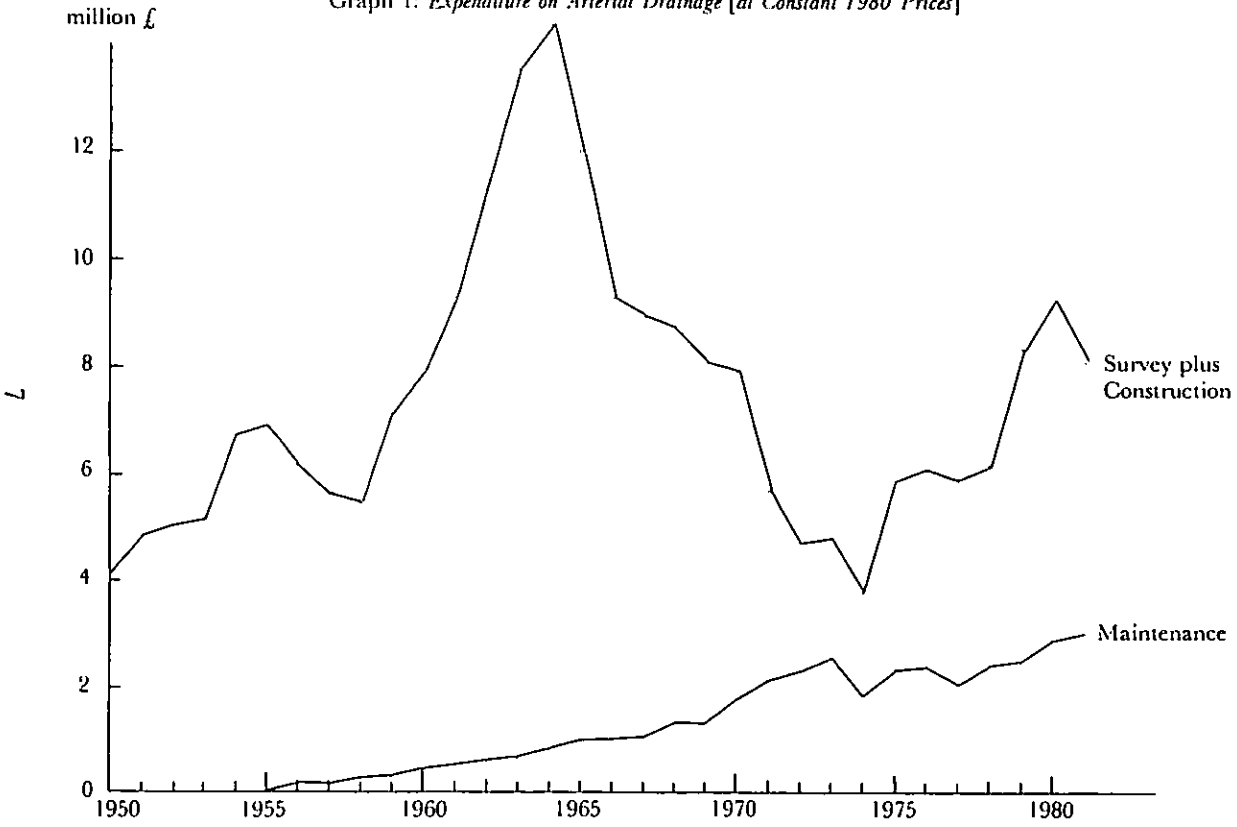
Review of Activity (1945:1980)

Since the Arterial Drainage Act (1945) was passed, 34 schemes have been completed, and a further three are in progress. Just over 600 thousand acres of land will have been influenced by drainage when these are completed. Over this time £238 million (at 1980 prices) were invested in survey and construction of schemes by the Office of Public Works (OPW). On average, arterial drainage has absorbed 1½ per cent of the Public Capital Programme; it has constituted about 12½ per cent of state capital spending on agriculture.

The level of investment in arterial drainage grew steadily from the time the first scheme started on the Brosna in 1948 up to

1. Under the 1842 Act, 250 thousand acres were drained, under the 1863 Act 130 thousand acres, and under the 1925 Act 70 thousand acres.

Graph 1: *Expenditure on Arterial Drainage [at Constant 1980 Prices]*



the mid 'fifties. (See Graph 1 and Appendix Table 1.) In the late 'fifties it slumped when the government made widespread cuts in capital spending in an effort to protect foreign reserves. In 1959 the programme was restored and the volume of spending doubled in the ensuing five years. The mid 'sixties was the heyday of drainage activity. Towards the end of the decade the level of work dwindled away. By 1972 it had fallen to only one-third of its peak level. However, in the wake of EEC membership the programme took on a new lease of life. As we enter the 1980s the drainage programme has recovered much of its former vibrance.

Table 1 summarises the progress of the drainage programme in each decade. Expenditure is shown in constant 1980 building prices: it is divided into capital spending on the survey and construction of new arterial schemes and current spending on maintenance of existing schemes. Capital costs per acre drained almost doubled from the 'fifties to the 'sixties, but fell significantly in the 'seventies.[2]

Table 1: *Progress under the central government's arterial drainage programme*

		Survey and construction of drainage schemes (capital spending)			
	Maintenance (current spending) (£000 1980)	*Spending* (£000 1980)	*Average of annual % of public capital programme*	*Acres drained* (000 *acres*)	*Cost* £1980/*acre*
1950-59	988	57,202	1.5	211.0	271.1
1960-69	9,102	104,005	1.8	205.3	506.6
1970-79	22,876	59,495	0.6	156.8	379.4

Notes and Sources: Same as for Appendix Table 1.

Central government spending on maintenance has grown dramatically over the decades. Under the 1945 Act, the OPW were required to maintain the new schemes it undertook "in

2. The choice of deflator is of considerable importance. Use of a building price index gives a sense of productivity performance in construction. Use of the consumer price index gives an idea of the tax take necessary to repeat the work in 1980. Building prices rose a good deal faster than consumer prices during the 'seventies; as a result, the tax take to repeat the work of the 'seventies would, in fact, be only marginally cheaper per acre than that of the 'sixties.

proper repair and effective condition". The maintenance of all previous drainage schemes was transferred from the existing Drainage District Boards to the County Councils. This was intended as an interim step on the road to integration under central authority.[3] In fact, the OPW has, with few exceptions, not taken over the maintenance of pre-existing schemes. The growth in maintenance spending occurred as newly completed schemes were put on maintenance. In 1980, it had reached £3 million for the year, or one-third of the relatively high capital spending - £9 million - of that year.

Outlook in the Eighties

As Graph 1 shows, spending on arterial drainage is almost back to its previous peak. It is being boosted by the EEC package of Aid for Western Drainage (1979). This will finance half of the money spent on drainage schemes in the West of Ireland. Under its five year programme, 54 thousand acres will be drained at a total cost of £19 million (£ 1980). Drainage of the Shannon has surfaced once again as a project likely to benefit from EEC aid. Already £1 million has been allocated to conduct the preliminary survey work.[4] If it goes ahead, this scheme will benefit 250 thousand acres, and will be more than twice as large as any previous catchment scheme. Apart from these, several schemes throughout the rest of the country are still on the government's priority list waiting to be done.

Environmental Implications[5]

Apart from removing surplus water from land, rivers fulfil many other important functions for the community. They provide public water supply, transport, and assimilative capacity for sewage and waste. Six of our rivers have been

3. In the meantime, the OPW were given powers to force Councils to maintain drainage works adequately. If the Council did not comply the OPW could enter and execute the work. The OPW could also apply to have the management of any works transferred to them by the Minister. However, the cost of all maintenance work (exclusive of OPW Head Office costs) were made payable by Councils of the counties benefiting.

4. However we gather that the survey work has been held up by the embargo on public sector personnel hiring.

5. The wider impact of drainage was addressed in a series of papers read at a conference on the subject in 1980. McCumiskey (1980) dealt with water resources, McCarthy (1980) with fisheries and Merne (1980) with wildlife. Most of the discussion in this section is drawn from these papers. Kelly (1980a and 1980b) also provides an overview of environmental impacts.

harnessed for power generation. Rivers and wetlands are the essential habitat of fish and wetland wildlife. In their undisturbed state they are also an important visual amenity. Arterial drainage may interfere with the present or future use of a river for these purposes.

Water Supply

McCumiskey (1980) notes that: "in the absence of development it is the drought flows that define the surface water resources that are available for meeting the demands of the various beneficial uses". The natural flow available can be augmented in various ways, such as storing the water by means of impoundments and/or by regulating the outflow from existing natural lakes, and by further development of groundwater resources.

For the country as a whole, total freshwater abstractions now amount to 58 per cent of the drought flows; allowing for fisheries and waste disposal needs, such a level of consumption could not be maintained were it not for the existence of water storage facilities and groundwater abstractions. It is expected that water demands could double over the next 20 to 25 years, and much of the increased consumption is expected to take place in the East, where the available surface water per capita is less than 9 per cent of that available in the Western and North-Western regions. There is no absolute shortage of water in Ireland. In many locations, however, we are at a stage when increased off-take can only be achieved by investing in storage and/or groundwater exploitation, or by sacrificing waste assimilative capacity and, therefore, fisheries and amenity values; economic choices have to be made.

With regard to the impact of arterial drainage on water supply, according to McCumiskey (1980) the most serious potential problems arise when single purpose arterial drainage schemes utilise natural lakes to alleviate flooding; they can significantly reduce the volumes of water available to augment low river flows and to support increased abstractions. He cites the case of the Erne catchment, where the Office of Public Works planned and designed a comprehensive arterial drainage scheme covering this area. In this scheme it was envisaged using the storage capacity of a number of lakes to attenuate flood

peaks. In a subsequent study by An Foras Forbartha, the feasibility of using these lakes to augment low flows so as to support increased abstractions and waste disposal was examined. It was found that these uses could be accommodated by controlling lake outflow and by retaining water levels in the lake systems at minimum recorded summer levels. Only small areas of marginal lands adjacent to the lakes would not have the full benefit of arterial drainage with this approach.

If the initial OPW design had been acted upon, these complementary - and in some cases very substantial - benefits would have been foregone; it is almost impossible politically, and may be very costly technically, to reverse such a decision after the work has been completed. If the OPW is made fully aware of these non-flood related dimensions of its activities, it is willing to adapt its project designs appropriately.

McCumiskey (1980) regards other water supply impacts as being of relatively modest significance. He observes that change which involves widening and deepening the river channel will reduce water tables and therefore "reduces the natural storage available to maintain low flows during periods of drought", but notes that "there is no evidence available that fully confirms that such channel improvement work materially reduces the magnitude of the lowest drought flows". He says that river channel improvements involving increased channel cross-section and increased depth of flows during drought periods can reduce somewhat a river's waste assimilative capacity, but that such reduction in the Irish context is "not considered to be of major significance".

A localised problem can arise when the groundwater level is reduced to the extent that existing wells run dry. For example, in an article in *The Irish Times* (Shanahan, 1980) it was reported that at least 13 families near the river Blackwater were left without water as a result of the adjacent arterial drainage project. This difficulty can be overcome by drilling deeper wells.

Fisheries

The degree and nature of disturbance to fisheries engendered by drainage is particular to the catchment involved. Key considerations appear to be the condition and nature of the river bed before drainage, the amount of re-grading required to effect satisfactory run-off in times of flood, and the composition of the

indigenous fish species (McCarthy, 1980). In certain circumstances, drainage works can have a beneficial effect for certain species in the long term. For example, the Bunree, a tributory of the River Moy, was studied in 1960, a year before drainage; and in 1962, a year after drainage was completed. It was found that recovery of the salmon was good; this condition has persisted with excellent spawning runs entering the catchment in recent years. McCarthy (1980) points out that sections of the river and its tributaries had heavy deposits of peat silt before drainage. The removal of these as a consequence of lowering the bed level exposed the boulder clay, and this increased the spawning potential of the system.

Conversely, pre- and post-drainage studies on all the major tributaries of the Boyne have yielded very disturbing results. They all have very small numbers of young salmon re-establishing, and most of these are stocked fish. For example, in the Timblestown River, prior to drainage salmonids were the dominant species, but over two years after drainage very few were present (McCarthy). Natural salmon stocks in the Boyne system are now dependent on the smolt production of a single river (the Blackwater). The decline in this instance appears to be due to the presence of large populations of predators, which impede salmon stocks recovery.

A major problem in rehabilitating fisheries is the need to maintain the channels. The Report of the Inland Fisheries Commission (1975) makes the point (p. 106):

> The impact on the fisheries of recurring drainage maintenance work gives cause for anxiety, and it is essential that this work also have particular regard for the fishery requirements. Otherwise it will be a continuing disruptive force, renewing the damage to spawning beds and preventing the natural recuperation of river channels from the initial impact of dredging.

The problem arises with particular force in some of those cases where drainage maintenance is undertaken by local authorities themselves. In such cases it seems that much of the work is done in the absence of supervision and planning; excessively large machines are used; "maintenance" proceeds on a periodic e.g., six or nine year, cycle, regardless of the state of recovery of the

stream or river (Whelan, 1981).[6]

In order to minimise the effect of arterial drainage on fisheries and reduce post-drainage problems with weed growth, Whelan suggests that *where possible* the following approaches should be adopted (Whelan, 1981):

(1) Minimise interference, removing only points (sills).
(2) Retain old channel, and leave in meanders.
(3) (a) Retain trees, removing lower branches.
    (b) Leave vegetation unharmed on one bank.
    (c) Remove vegetation from alternate banks in sections of 500-1,000 metres.
(4) Replant banks where possible with deciduous trees.
(5) Replace large boulders, stone and gravel.
(6) Dig pools at intervals.
(7) Drain in a stepwise manner so as to provide short riffle areas wherever possible which will break up the surface film and thereby increase aeration.

In some instances it will not be possible to comply with these suggestions. In others it will reduce the effectiveness of the drainage and/or increase cost. These costs - reduced farm income and/or additional project costs - must then be set against the resulting benefits to the fisheries, and other conservation/amenity values. However in still other cases these measures could reduce project and maintenance costs with only modest (if any) reduction in drainage-effectiveness.

Wildlife

Merne (1980) reviews the impact of arterial drainage on mammals, reptiles, amphibians and birds. He notes the particular habitat requirements and significance of various species, and the implications of drainage in these respects. Otters, for example, are still fairly widespread and common in Ireland, but "the clearance of riverside trees, scrub and other vegetation, and the grading of the banks make it difficult for otters to find suitable sites in which to make their breeding holts". He notes that the Black-necked Grebe is almost extinct in Ireland due to turlough drainage. He points out that this country's primary importance for wildfowl lies in its capacity as

6. Some of these ideas are also included in Swales (1981).

a relatively temperate wintering area at the end of migratory flyways from Greenland, Iceland, Scotland, Scandinavia, Central Europe and western Russia; with the reduction in wetland areas, these species are being concentrated into fewer and fewer areas, where they are coming under pressure from both hunters and shortage of food.

The Forest and Wildlife Service is responding to these pressures by surveying the remaining wetlands in order to identify those which are of greatest importance for wildlife. It is hoped that "cooperation, and liaison between conservation and drainage authorities will result in modification of drainage plans to accommodate wildlife conservation interests" (Merne, 1980). It is planned also to identify those wetlands which are of scientific importance by virtue of their general ecology and vegetation.

General Aesthetic and Amenity Considerations

Change in the landscape often evokes a generalised sense of loss in some people, even while they recognise that such change may be beneficial financially. Rivers in their "natural", i.e., relatively undisturbed, state, and the associated trees, shrubbery and verges are especially evocative in this respect; memories of riverside picnics, walks, trysts, boating trips, childhood adventures etc., often do not easily yield to the scouring, scraping and de-nuding of vegetation associated with conventional arterial drainage, nor to the resulting relatively homogeneous and geometric appearance. This sense of identity with unmodified rivers resulted in the US in the statutory designation and protection of what are called "wild and scenic rivers"; those rivers or stretches of rivers so designated cannot be modified except in exceptional circumstances. We are not arguing here that such an approach is necessarily desirable in Ireland; we are saying that the loss of a sense of identity which results for some people when a river is significantly modified is a consideration to be weighed in the balance against the benefits of such modification.

Environmental Considerations and Economic Analysis

Since fishing, hunting, wildlife observation, recreation, scientific considerations and aesthetic dimensions are not by

and large purchasable and exchangeable in well functioning markets, we have no independent and universally acknowledged litmus as to what price would accurately represent the willingness to pay for the dimension in question.

With regard to recreation, there is a vast literature - originating mainly in the United States - devoted to evaluating the willingness to pay for recreation experiences. It is important to be clear on what should be measured in this respect: it is what recreationalists would be willing to pay in aggregate *at the site in question* for admittance to the experience, i.e., what they would be willing to pay after they have incurred equipment and transportation costs. This is analogous on the farming side to the addition to farm income resulting from drainage. Two broad means of imputing such willingness to pay have found favour.

The first uses travel costs. In this approach the visitors who travel farthest are assumed to be marginal in the sense that their willingness to pay is assumed to be zero; if they knew that they were to be faced with an entrance charge at the recreation site in question they would not go at all, or they would have gone elsewhere. All other (closer in) visitors are assumed to reap a "surplus", equal to the difference between the transportation costs of the marginal visitors and those which they incur themselves. This difference is assumed to comprise the maximum willingness to pay for admission to the recreation experience. Although this approach has the advantage that it is based on actual rather than hypothetical behaviour, it depends for its validity on a set of highly restrictive assumptions (only some of which can be relaxed by making the model more elaborate), and it is in any event only applicable to a particular sub-set of recreation types.

The second recreation evaluation methodology is called the interview approach, whereby users are asked their willingness to pay. To reduce bias, this question is typically approached indirectly, by, for example, in the case of hunting, first getting an estimate of total expenditure on guns, shells, transportation etc., and then assaying, through a mock-bidding process, to what level maximum total costs would have to rise before the individual would first reduce and then desist altogether from hunting. The difference between existing and maximum costs comprises the willingness to pay for the experience. In

comparison with the travel cost method, this approach has the great disadvantage that it is based on hypothetical rather than actual behaviour, but this is compensated for to some degree by the greater flexibility it allows in application.

We have not done justice to the ingenuity of some of the refinements which have been introduced to these basic frameworks, but sufficient has been said to make clear the profound limitations which these (and any other) approaches share. They apply to only active users of the recreation/amenity values, and cannot easily distinguish qualitative differences. Thus in *The Irish Times* article cited earlier concerning the drainage of the River Blackwater, Co. Meath, (Shanahan, 1980), one resident is quoted as saying "I'm not a fisherman, but the fishermen I've talked to say that it's no longer a pleasant river to fish, more like a canal". Presumably there are other fishermen who prefer fishing in canal-like conditions, but how can both of these contrasting qualitative perceptions be adequately captured in the evaluative metric? For much - perhaps most - of the amenity conservation value, there is no immediately identifiable group of beneficiaries. Lovers of wildlife may rarely visit the catchment area *per se*, but still suffer loss if breeding and feeding areas are destroyed. For unique areas and species, there can exist what economists call option value; option value exists when there is a willingness to pay to retain for future use an area of uniqueness for which no close substitutes exist, even if this option is not exercised. Thus, for example, in Ireland there may be a willingness to pay to keep the Wexford Wildfowl Reserve in its present use on the part of some of those who have never visited it, and perhaps never will; they want the option to remain open to them. A closely related concept is that of vicarious consumption; this is comprised of the satisfaction derived from simply knowing that certain rare or remarkable species and environments exist.

While one can plausibly posit the existence of such values, it is manifestly impossible to arrive at benefit valuations which would be accurate and achieve widespread acceptance. There is the further difficulty that in Ireland many perceptions concerning the environment are almost totally uninformed, and values are, therefore, likely to change as knowledge improves. Thus, for example, when Merne (1980) observes that the Black-

necked Grebe is almost extinct as a breeding species in Ireland due to turlough drainage, or that between half and three-quarters of the world's population of Greenland White-fronted Geese depend on a few sites in Ireland for their winter feeding and resting area, this information will probably evoke little more than a yawn from those with little background, while exciting interest and concern in those who do. Since knowledge, interest and awareness of natural systems is growing, we can expect a commensurate increase in the value which informed people place on the protection thereof.

The difficulties in arriving at a credible estimate of willingness to pay for the preservation of areas of scientific interest are also intimidating. Natural biota represent our reservoir of germ plasm, to which we must turn in order to introduce new genetic strains into cultivated plants. Many drugs are derived from botanical specimens; examples include digitalis, heperin and cortisone. Since we do not know which species may in the future prove to have medicinally valuable properties, eliminating species means forgoing future options. Since arterial drainage in Ireland rarely, if ever, poses the stark choice of drainage versus total species elimination, the above considerations are not usually germane. The more mundane matter of choosing between drainage and the preservation of a representative, but not unique, ecosystem provides a near impossible evaluation assignment, since a credible value cannot be assigned to the research or other outputs resulting from such preservation.

Given the valuation difficulties, how are these non-market considerations to be incorporated in the economic analysis? It is a central tenet of this paper that if the investment appraisal of the choices which can be valued using market prices is done appropriately, then some potentially environmentally adverse decisions will not be made, i.e., there are investments which on economic efficiency grounds should not be undertaken; the environmental costs in such cases do not need to be calibrated to reach a decision. Conversely, there are investments which can be fully justified on economic efficiency grounds which also have incidental but very beneficial environmental effects. A striking example in this latter category was reported by the Steering Group in their analysis of the River Maigue drainage scheme (Steering Group, 1978). It was discovered that if the spoil (the

dredged up soil and detritus from the river bed and banks) were to be spread rather than piled in untreated spoil heaps (as had been the practice), this would yield a net farm income increase almost four times the additional cost, and would also have beneficial environmental (including aesthetic) effects. Thus, the first rule is to make sure that the proposed incremental investments are economically efficient, because in some cases what is efficient, based on market valuations only, will also be environmentally benign.

In instances where, to use the business studies terminology, the decision is not dominant (all criteria favouring a particular course of action) then trade-offs have to be made. The analyst can make an important contribution by indicating the magnitude of the sacrifice required in terms of net market-valued output so as to accommodate the non-market values. To do so, however, the analysis must be structured in an incremental framework. The additional costs incurred and corresponding returns yielded as the scale of the scheme is expanded must be presented. Furthermore, the environmental implications of each increase in scale need to be addressed, however qualitively this must be done initially. When information is presented in this fashion, it is possible to identify when a small net financial gain is achieved at a major loss to the environment and vice versa. In order to apply this effectively, both the financial and the environmental data must be presented in a marginal framework. With regard to the latter, in addition to its use for trade-off analysis, it also facilitates the identification of thresholds, which can be of great value. It can be the case that the carrying capacity of an environment is not fully utilised by a particular species, and habitat removal/modification can, therefore, proceed with little damage to populations. However, when the carrying capacity is fully utilised, this disruption of habitat can only take place at the expense of the biota in question. At a further stage of development, habitat disruption can only take place if species extinction - local, regional, national or global - is countenanced. It is important, at least, to attempt to work towards the identification of these and other threshold points, however imperfectly they can be defined at this stage. We hope that the EEC-funded study of the

environmental implications of arterial drainage which is now underway will be designed in this fashion.

Field Drainage

The state was much slower to get involved in field drainage. The first scheme of grants was introduced in 1931. Progress was modest. Only 140,000 acres benefited under the scheme in twenty years of its operation. A major handicap was the lack of specialised machinery for the work.

After the Second World War, the opportunities for field drainage had improved. The arterial programme had started. As it opened up better river outfalls, more fields could be profitably drained. Appropriate machinery had also become available. Accordingly, the Department of Agriculture launched a major scheme of field drainage and land reclamation, known under the title of The Land Project (1949).

When the Land Project was introduced, a survey by officers of the Wartime Compulsory Tillage Campaign indicated that 4½ million acres of farmland needed some form of improvement to reach maximum productive capacity. The estimate was later increased to 6 million acres, as the use of heavier farm machinery exposed drainage deficiencies. On about 5 of the 6 million acres inadequate drainage was identified as the main inhibiting factor.

In 1974 the Land Project was superseded by the Farm Modernisation Scheme. The latter brought the assistance for field drainage into conformity with EEC directives for farm development. It was augmented by a special programme of field drainage for the Western Counties initiated in 1979. All of these schemes have offered *grant* assistance towards the cost of work carried out by the farmer. Initially the Land Project also offered an option where state contractors did the work, and farmers made a part contribution. However, this option was withdrawn in 1958, and indeed had been largely inoperative for a year or two before.

Review of Activity 1949-80

Since the Land Project was launched in 1949, state assistance has contributed to the improvement of just over 3 million acres,

amounting to 20 per cent of arable and marginal land. The total cost of this work was some £600 million (at 1980 prices) of which the state bore £350 million (58 per cent) in support payments. More than four-fifths of the work was on field drainage and the rest on land reclamation. Excluding reclamation, the state spent about one-third more on field drainage than on arterial drainage in the post-war period. On average, land improvement absorbed 2 per cent of the Public Capital Programme, comprising about 18 per cent of state capital spending on agriculture. Its share in the Public Capital Programme has been steadily declining during the post-war period.

Despite the variety of schemes supporting land improvement in the past thirty years, the overall rate of progress has been remarkably steady in each of the three decades (see Table 2). This uniformity conceals considerable year-to-year fluctuation (see Graph 2 and Appendix Table 2). The work rate fell in the late 'fifties when the state narrowed the range of options under

Table 2: *Progress under various field improvement schemes*

		Cost of state assistance £ 1980		
	Area improved (000 *acres*)	*Total* (£000)	*Average of annual share of PCP* (%)	*£ Per acre*
1950-59*	968.2	117,050	3.1	120.9
1960-69	935.6	121,427	2.1	129.8
1970-79	1041.2	99,664	1.0	95.8

*Includes work directly done by the state.
Notes and Sources: As for Appendix Table 2.

the Land Project, and recession also reduced investment by farmers. Throughout the 'sixties and 'seventies the work rate followed a ratchet pattern. Periods of gradual decline were followed by steep rises. The most likely reason for the decline was the fixed money grant ceiling per acre. Rising costs eroded the effective rate of grant as it pressed against this ceiling. The steep recovery occurred when the ceiling was relaxed in 1965, and again with the introduction of the new schemes in 1974 and 1979. The outlook is that the present peak work rates will be

Graph 2: *Acres improved with state grant-support and grant cost per acre*

sustained, at least during the early 'eighties when the generous Western Drainage Scheme is in operation. This scheme alone is programmed to drain 325 thousand acres in 1979–83, and work in the rest of the country is still buoyant.

The real cost to the state has varied quite a bit and we will look more closely at this in a later section.

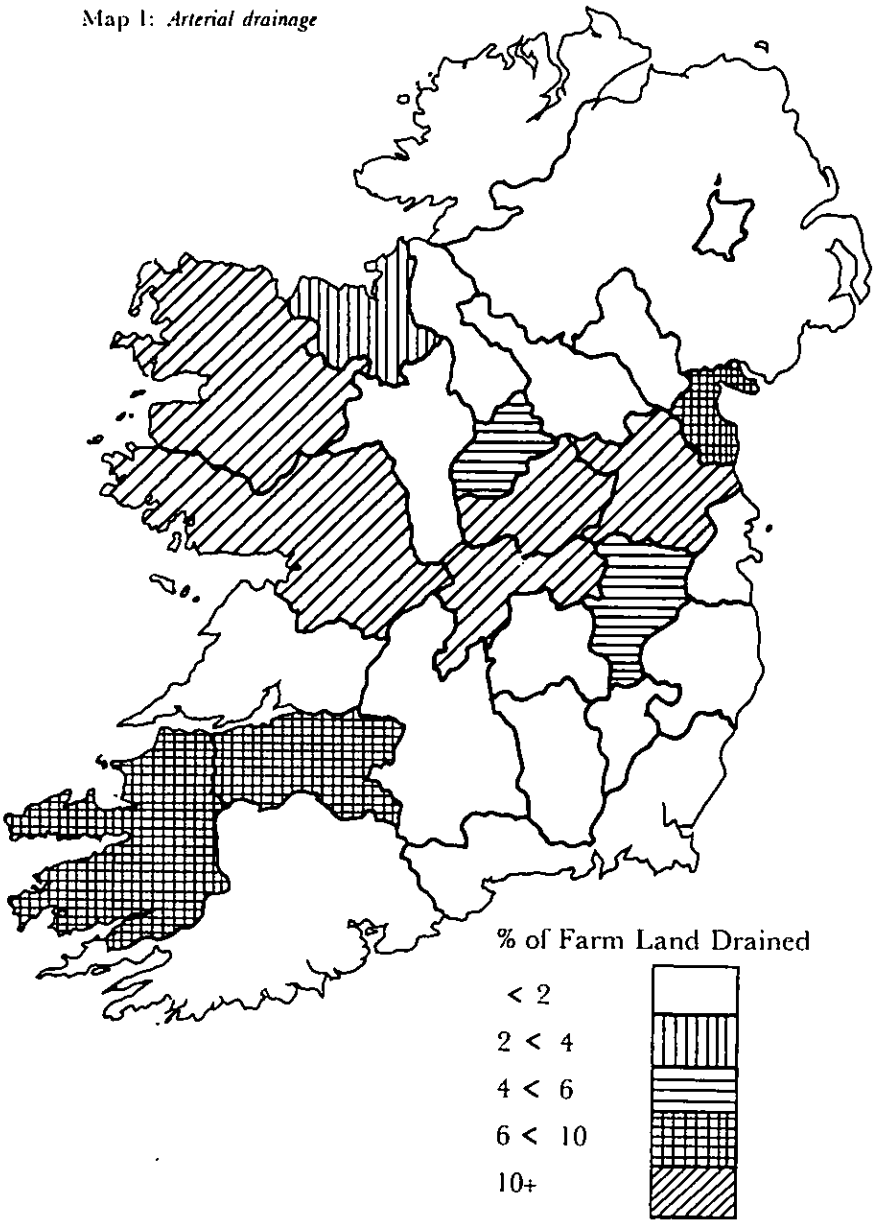
Regional Summary of Arterial and Field Drainage

Since the war, roughly six hundred thousand acres of arterial and three million acres of field drainage have been completed. The acreage affected by arterial drainage cannot be simply added to the latter. Normally the farmer has to follow up with field drains to reap full benefit from improved river outfalls. For instance, in four catchments recently appraised for arterial draining, three-quarters of the land affected needed follow-up field work. Unfortunately, no records have been kept to indicate whether farmers have, in fact, done the follow-up work in drained catchments.

The pattern of drainage has been far from uniform across the country. Maps 1 and 2 give the broad impression of the proportion of land drained under each programme across the country. The arterial work has been virtually all north and west of a line running from Dublin to Killarney. On the other hand, the concentration of field drainage has been in the South-East. The counties west of the Shannon have field-drained a far smaller proportion of the land. This pattern is not surprising. River outfalls are better in the South-East, so it has been economic for farmers to drain fields of their own accord. In the West, many farmers have had to wait on arterial improvement before field work would pay. However, the arterial programme has now made great strides in the West. High grants for field drainage now available in the West are intended to encourage farmers to exploit the benefits from this work.

Table 3 summarises the provincial progress in drainage prior to the introduction of the Western Drainage Scheme in 1979. (The full county data are shown in Appendix Table 3). Leinster has fared well under both programmes. Connaught has above average arterial drainage but is well below average in field drainage. In the Western Drainage Scheme eleven full counties

Map 1: *Arterial drainage*



Map 2: *Field drainage*

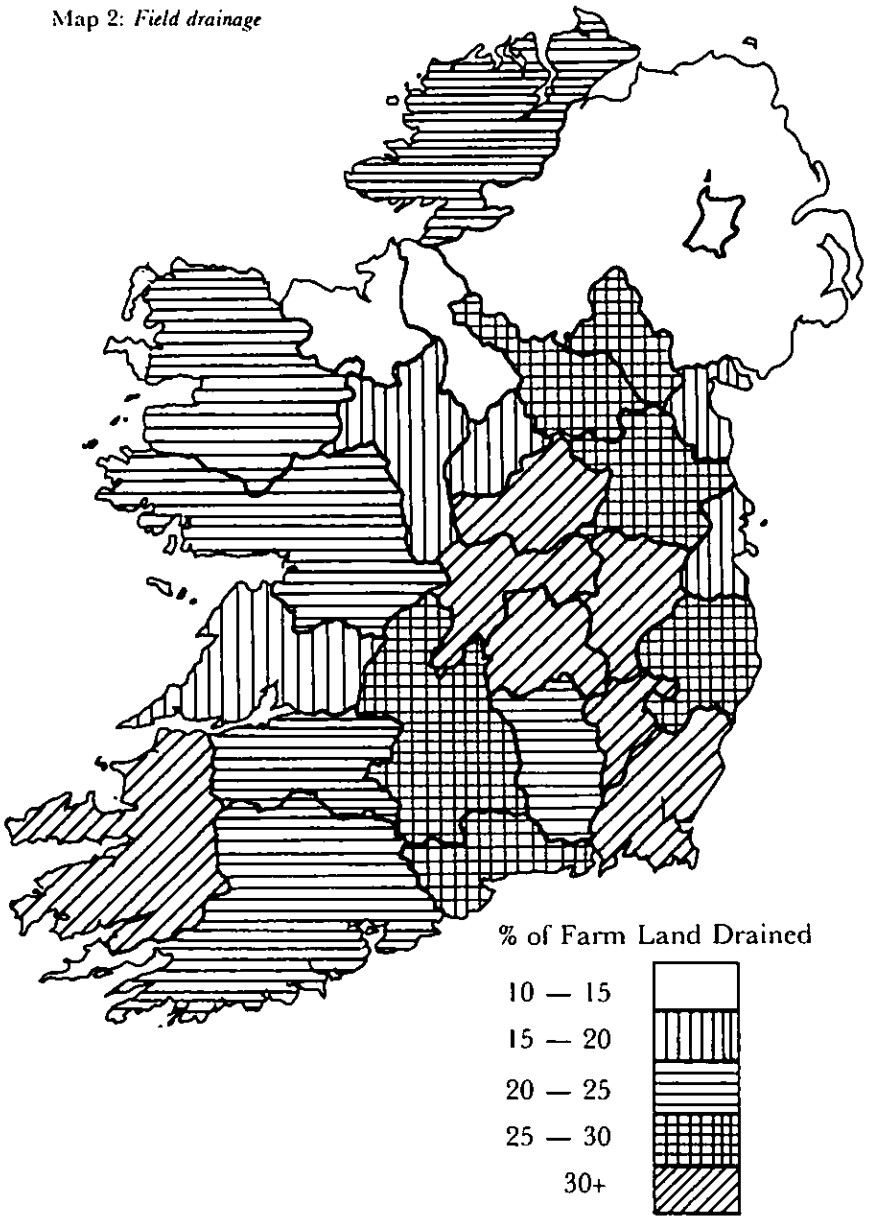


Table 3: *Regional performance of drainage programmes*

	Area improved			
	Field		*Arterial*	
	Acres (000)	*% of farm land*	*Acres*	*% of farm land*
Leinster	1,127	28.5	288	7.0
Munster	1,001	23.5	114	2.7
Connaught	479	19.1	196	7.8
Ulster (3)	280	24.7	20	2.5
Designated Cos.	1,054	21.2	276	5.5
Non-designated Cos.	1,834	26.6	342	5.0
Total	2,888	24.3	618	5.2

Notes and Sources: As for Appendix Table 3.

have been "designated" as eligible for special field-drainage grants and new arterial schemes. These counties are long established as ones with difficult farming conditions. Four of them have enjoyed few benefits under either scheme in the past. The others have already made considerable strides.

II ECONOMIC CONSIDERATIONS

If drainage pays, why not let the landowner get on with the job, incurring the costs and reaping the benefits? We now have a well-functioning set of lending institutions in place, eager to advance funds to individuals who have profitable investments to make. Why should the general taxpayer incur a large proportion of the costs, with the return accruing to the participants in the programme? There are a number of reasons for public involvement.

Public Goods

Drainage - and especially arterial drainage - is what economists call a "public good". This is defined as a good which, if it is available to one, is automatically available to all; the usual examples given are improved air quality and national defence. If a catchment area is drained, it is impossible to prevent landowners in the area from benefiting. This gives rise then to what economists call, aptly enough, the "free-rider" problem. The individual landowner will say to him or herself, "why should I contribute to this endeavour, since, if it is undertaken, I'll benefit whether I contribute or not?" Thus investments in public goods which can be fully justified on a financial efficiency basis will fail to be undertaken because the incentives for the individual landowner are wrong. Such conditions are said to result in "market failure"; the market is inhibited from playing its customary role of efficient resource allocation.

Transaction Costs

In addition to the public goods - free-rider - problem, there is another source of market failure. Even if everyone who would benefit were willing to contribute commensurately to the cost of undertaking the scheme, the system could still break down because the costs, both monetary and otherwise, of organising a

disparate group of landowners, assigning the appropriate charges, collecting the money etc., can be so large that progress is stymied on this account. These costs are called "transactions costs" in economics parlance.

Externalities

Thirdly, and of great relevance to our topic, there are externalities involved; these provide another source of market failure. An externality is said to exist whenever one does not reap the full gains (positive externality) or bear the full costs (negative externality) of one's actions. Economists regard environmental degradation as a classic manifestation of negative externalities. The environmental media - air mantle, water courses, wetlands, the sea - can be used as "free" disposal areas for waste products; the costs which such disposal imposes are not borne by the perpetrators, and so the latter have no incentive to conserve their use of environmental resources.

As we have seen, drainage can impose negative externalities, by disrupting fish life, destroying wildbird and wildlife habitat, threatening rare and endangered species and habitats, etc. The benefits of retaining an area as a wetland for bird habitat, for example, will typically not accrue to the owners of this habitat, whereas they can capture the full benefits resulting from the drainage of this land. There is, therefore, a "wedge" driven between their self-interest and the larger public interest, which will result, other things being equal, in the "under-conservation" of wetlands. Within a catchment, another form of externality can be imposed, if drainage by landowners upstream exacerbates the flooding problems of those downstream. Drainage may also provide positive externalities, e.g., the diminution of flooding of houses, commercial/institutional premises and boglands.

Income Re-distribution

Finally, drainage can be used as a means of re-distributing income, of using tax revenues to enhance the productivity of the land belonging to the more deprived members of our community.

When the market is failing, there are often (but not invariably) good economic efficiency arguments for government intervention. By having government undertake arterial

drainage, we overcome the free-rider problem, or, more accurately, we universalise it by making all beneficiaries "free-riders". This also overcomes transactions costs. In the case of arterial drainage, the Office of Public Works has been given full authority to conduct surveys, undertake construction and maintain the arterial drainage system, all supported entirely by government funds; the surveys and construction costs are borne by the central government, while maintenance is charged to local rates.

While government can intervene usefully and successfully in this fashion to compensate for market failure, clearly this approach creates its own perverse incentives. Once a good is provided to individuals at no charge beyond the costs incurred by the landowner to "tie-in" to the system, demand for this good will far exceed what it would be if landowners bore the full costs themselves. It follows that the existence of an "unmet" demand for drainage under these circumstances does not imply that it should necessarily be met. It is sometimes argued that the existence of a pressing and ever-present demand for drainage works on the part of prospective beneficiaries of itself justifies spending public money to this end. However, if the government undertook to provide free calves, fertiliser, or pints of Guinness, there would likewise be real and pressing demands for these goods. Given an unsatisfied demand for a highly subsidised service, the government must ration it. If it is interested in economic efficiency, it can do so, in effect, by attempting to choose among alternatives so as to maximise the resulting net benefits. Because of its "public goods" nature, there is an economic efficiency rationale for government intervention in arterial drainage.

The rationale for public intervention in field drainage is less clearcut; some landowners could drain their land independently of what other landowners do, i.e., the effectiveness of their investment does not depend on the actions of others. In such cases there are no market failure reasons for public intervention. If the investment pays, the landowners should undertake it; if not, they should not. There are no economic efficiency arguments for government intervention or subsidy. However, there are other cases where interdependency effects exist; the effectiveness - and in some cases, feasibility - of what a given

landowner can accomplish depends on the actions of other landowners, while in other instances drainage by some owners can increase the flooding incurred by others. There can be a case here for government intervention on economic efficiency grounds.

There is a further, pragmatic, reason for government intervention. The "success" of any arterial drainage scheme depends on the extent to which landowners undertake the necessary follow-up field drainage. If, in spite of the fact that it would pay them to do so, owners in sufficient numbers do not undertake the follow-up work, then a subsidy may be necessary to encourage the requisite work. Finally, landowners may discount future benefits at a much higher rate than "society", and, therefore, under-invest in drainage. This is especially likely to obtain in the case of elderly landowners, who themselves are unlikely to reap the full benefits of such investment.

Given that government intervention in drainage can be justified, it is helpful to examine the nature and effectiveness of such intervention in the context of economic efficiency.

Economic Efficiency

The most economically efficient allocation of resources occurs when the (time-adjusted) difference between benefits and costs is maximised. In the case of private investment, this is synonymous with the allocation which maximises net revenue. Given certain assumptions, when all inputs save one are fixed, it can be identified as the input level where the marginal cost of the last input added just equals the increment in revenue thereby produced. In the case of multiple inputs, a necessary condition for the achievement of efficiency is that the returns at the margin to the last unit of expenditure on each input be equal.

These rudimentary pointers to the most economically efficient allocation of resources are here outlined because they are of central relevance to the analysis of choices concerning drainage; we will draw on them later when we evaluate existing approaches and provide suggestions.

There are four interrelated mechanisms available whereby economic concepts can be utilised to encourage economic efficiency. These are: pricing of the drainage services provided,

so as to encourage both the appropriate level of drainage and the efficient use of its beneficial effects; providing an institutional structure wherein the drainage authority is responsible in some sense for all of the significant impacts - beneficial and adverse - resulting from its activities; supplying an appropriate analytical framework for examining the cost and benefit implications of alternatives; providing, within this analytical framework, an appropriate means of evaluating investments.

Pricing

If landowners were to be charged the full cost of the drainage services provided, in the same way that, for example, they pay the full cost of a tractor delivered to their farms, this would ensure that in most cases only projects would be undertaken which were expected to yield a return in excess of those costs.

In the case of arterial drainage, in the earliest schemes undertaken by government in Ireland[7] a significant proportion of the costs was borne by the benefactors. In those days the scope of the schemes was smaller and there were relatively few major landowners, so that transactions costs were much lower. In addition, there was little or no tradition of direct government subvention of private endeavour. Now, because of the scale of schemes and the very large number of landowners - over 2,000 landowners were expected to benefit from the River Maigue arterial drainage scheme - it would make it difficult to undertake drainage by consent of all the owners if full payment by the latter were required, while compulsory charges would give rise to other difficulties. With the current trend in the direction of abolishing rates on land, this mechanism does not look promising as a means of recouping some of the capital costs. However, the benefits of applying some charge - in terms of both avoiding inefficient investments and providing funds to the drainage agency - are so compelling that in our view alternative approaches to securing at least partial payment should be explored. The cost-sharing provisions of the rural group water supply schemes provide a possible model applicable to land drainage.

If it is accepted that - as suggested earlier - a farmer will combine inputs such that the returns at the margin to the last

7. This history is discussed briefly later on.

unit of expenditure on each input will be equal, then more heavily subsidising one activity, e.g., drainage, than others will result in reduced net output for the economy. To illustrate this effect in a highly simplified and exaggerated form, take a farmer who is choosing between two investments which are expected to have the cost and revenue patterns illustrated below. It is assumed that the appropriate adjustments have been made for the impact of time:

	A	B
Total Cost	1,000	1,000
of which farmer pays:	500	900
Subsidy	500	100
Total revenue	1,100	1,400
Net return to farmer	600 = 1,100 - 500	500 = 1,400 - 900
Net return to nation	100 = 1,100 - 1,000	400 = 1,400 - 1,000

If these are mutually exclusive investments (only one of the two can be undertaken), while it is clearly in the national interest to undertake B - it will yield four times the return to the nation that A will provide - it is nevertheless in the farmer's interest to undertake A, since it shows the higher net return to him/her. This illustrates, in a highly exaggerated form to be sure, the manner in which aggregate national farm (or other) output can be diminished when incentives are not uniform across production opportunities. This in turn means that there are fewer resources available to invest in the production choices or to otherwise support landowner income. The impact on the Exchequer is also perverse. For example, in the above case, if the subsidy for enterprise B were increased from £100 to £250, then the landowner would choose B or A, since his/her own outlay would fall to £750, and his/her net return would amount to £650 (1400-750). In addition to producing more wealth for the nation, this would also "release" £250 of taxpayers' money (500-250) for expenditure elsewhere in the economy, given that these alternatives are mutually exclusive. The latter consideration is not an economic efficiency concern *per se*, but it is of some moment to managers of the government's finances.

If investments A and B are independent (either or both can be undertaken) it is in the national interest that both be undertaken.

Generalising from this experience, we can say that, for a given aggregate amount of input subsidies, net return to the nation will be maximised if the subsidy rate per unit of cost is invariant for all inputs, provided that there are not some specific positive externalities associated with a particular input which would justify a higher rate of subsidy.

Institutional Structure

With regard to arterial drainage, the Office of Public Works has been given a single primary mission - to drain land. It does so at a catchment level, so that we can expect that interdependencies *vis-àvis* flooding within this area will be appropriately accounted for in project design.

The agency does not have a statutory function in water supply. If the relevant local authorities inform the OPW of their water supply requirements at the project design stage, these can be accommodated. However, the local authorities may be insufficiently aware of the water supply implications of schemes at an early stage, and miss the opportunity to request an appropriate change, forgoing thereby a very cost-effective opportunity to augment future water supplies. Likewise, although the OPW has legislative requirements to consult the appropriate bodies concerning fisheries, wildlife and amenity impacts, these concerns are not an integral part of the agency's responsibilities; it has to depend almost exclusively on the advice of other units of government in this regard in formulating and carrying out the scheme. Analogously with the case of water supply, the onus of making the case rests with the environmental interests. Thus the OPW has neither the legislative authority nor the organisational structure to fully internalise all of the costs and benefits associated with drainage, although in recent years it has widened the scope of its concern in this regard.

Analytical Framework

In order to assess the net impact of drainage, it is necessary to estimate the prospective impacts if the land had not been drained, and deduct these from the estimated impacts with drainage. This "with-without" approach should characterise all evaluation.

The analysis of alternatives should proceed marginally,

starting with a comparison of the costs and returns of the minimum scale project, and then iteratively examining prospective enlargements and the associated costs and benefits.

The analysis should examine alternative means of achieving the same objective. Thus, in addition to drainage, alternative means of expanding net income should be explored.

The validity of assumptions and predictions should be constantly tested against the actual outcomes, by undertaking continuing *ex post* analysis of completed projects.

Evaluating Investments

The Rate of Interest: In evaluating investments it is necessary to adjust for the fact that costs and returns occur at different times. In the case of private sector investment when the firm is using its own funds, this is usually done by discounting the expected cash flow back to the present - year zero - at a rate of interest which reflects the rate of return which would be yielded by the best alternative investment (if this is above the borrowing rate), other things (risk, etc.) being equal.

In the case of public sector investment it is argued by some that society's rate of time preference - the rate at which society as a collectivity discounts the future - is the appropriate interest rate to use. In this latter regard, the assumption is usually implicit that individual consumers and producers are "myopic" about the future, and that the collective rate of time-preference will be lower than the average of individual discount rates.

Unfortunately, in Ireland we do not know what the rate of return is in the best alternative investments. Still less do we know what the collective rate of time preference might be. With regard to the former, some of the larger companies use a real rate of 10 per cent in evaluating proposals, but few firms are returning a before tax real (net of inflation) rate of return of this order. It can be argued that the relevant opportunity cost for an open economy with a balance of payments deficit of drawing funds into investment is the real cost of foreign borrowing. Although it is difficult to estimate, primarily because of the prospective impact of exchange rate changes, the real cost of foreign borrowing by the government is probably in the range of 0-5 per cent. The real rate of return earned on some (purportedly commercial) state investments seems to be negative.

Most analysts seem to feel that the real long-term risk-free rate of return at the margin to investment in Ireland falls in the range of 2-6 per cent. However, this has not been validated by a comprehensive analysis of opportunity costs at the margin.

All costs (including the interest rate) and revenues should be expressed in either real -i.e., net of inflation - or nominal - including inflation - terms. If the real rate of interest is four per cent and the rate of inflation is 18 per cent, the nominal rate which would be equivalent to a real rate of four per cent is 22.72 per cent ($1.04 \times 1.18 = 1.2272$). Since inflation rates are difficult to predict, we feel that it simplifies analysis if all of the data are expressed in real terms. However, anticipations concerning changes in future real prices should, of course, be incorporated into the analysis.

The Criterion: When mutually exclusive investments, i.e., only one of which can be undertaken, are being evaluated, the one which yields the greatest present net worth (difference between returns and costs discounted to year zero) is to be preferred. The alternative which yields the highest benefit - cost ratio is *not* the optimum, and neither is that which shows the highest internal rate of return (the average rate of return on the investment). This can be illustrated in the simple example below, where two *mutually exclusive* investments - A and B - are being evaluated. The discount rate is 5 per cent.

Data

Year	*A*	*B*	*B–A*
0	-10	-40	-30
10	40	100	60
Results			
Present net worth	14.6	21.4	6.8
Internal rate of return (%)	14.9	9.6	7.2
Benefit/Cost ratio	2.46	1.53	1.23

Here B has a higher present net worth than A, but the former has both a lower internal rate of return and benefit-cost ratio. This results because, while the average rate of return on A is higher than it is in the case of B, by spending an additional 30 units to invest in B, present net worth can be increased by 6.8.

However, since this *increment* shows an internal rate of return of 7.2 per cent, which is below the average rate of return yielded by A (14.9 per cent), adding this increment pulls down the internal rate of return on B to 9.6 per cent; the benefit-cost ratio is similarly affected. Thus choosing the alternative which maximises either the internal rate of return or the benefit-cost ratio can mean forgoing increments at the margin which return more than they cost. This only applies when the alternatives are mutually exclusive, i.e., only one can be undertaken. If the alternatives are independent - either can be undertaken - then both should be, since each yields a net return.

If sufficient funds are not available to undertake all of the independent projects showing a positive present net worth, and constraints are expected to persist in the future, then the specified interest rate is not a true measure of the displaced alternative projects, i.e., the rate of discount is inappropriate. The ranking problem then becomes a programming one. The maximand is the present net worth of the combined projects, subject to the set of budgetary (and any other) constraints. Hawkins and Pearce (1971) note that, because of the very demanding data requirements involved with multi-period capital rationing problems, a number of writers have recommended a second-best solution: that investors rank independent projects in order of internal rate of return,[8] and undertake projects in each period until the budget is exhausted.

Time Horizon: Investments should be compared over the same time horizon. If they have unequal lives, this can be adjusted for by comparing the annual equivalents; the amount which, if received annually over the period, and discounted to the present, would equal the present net worth.

Shadow Pricing: Thus far, the matters we have considered apply equally to public and private investment. However, when markets fail, and government investment is undertaken, it may be necessary to derive proxy "shadow" prices for those inputs and outputs which are either not exchanged in markets, or where it is judged that, though exchanges take place, the prices emerging from markets do not reflect adequately social costs and benefits.

8. Note that this does not apply in the case of mutually exclusive projects.

In the case of drainage, estimating the net additional income accruing to landowners as a consequence of the proposed investment is the primary shadow pricing exercise on the benefit side. If land price differences captured appropriately the present net worth of the additional income stream resulting from drainage, these could be used directly as estimates of the benefits.

On the cost-side, in an earlier section we discussed the difficulties in deriving appropriate shadow prices for the environmental impacts. Labour inputs are the other major category of input for which shadow prices are derived. If prospective workers on the project are unemployed, and this situation is expected to last for the duration of the project, employing these individuals will not result in a reduction of output elsewhere in the economy. Since the opportunity cost in terms of output therefore is zero, it is argued that these workers should be assigned a shadow price of zero for social costing purposes. However, if leisure has positive value for the individuals involved, then the sacrifice involved in forgoing it should be netted out. In such cases the minimum wage necessary to induce participation – the minimum acceptance wage – is the appropriate shadow price to apply. There may be other (probably fewer) instances where the individual(s) involved would be willing to pay in order to be allowed to work; in these cases, instead of being a project cost, employment becomes a benefit.

If input shadow pricing is undertaken, it is important that the interest rate which is chosen to discount the cash flow be consistent with this practice. We noted earlier that we feel that the real rate of return to investment at the margin in Ireland falls in the range of 2 to 6 per cent. This range is based only on commercial criteria, and does not incorporate any adjustment for shadow pricing. If, in the case of a private investment, the wages of the workers who, in the absence of the investment would be unemployed, were shadow priced at zero, then, of course, the (social) rate of return on the investment computed incorporating this adjustment would be higher – considerably so in many cases – than the commercial rate of return, which is based on actual cash outlays and returns. Thus, if shadow pricing is engaged in, consistency requires that the discount rate

applied should also represent the alternative rate of return at the margin to investment, *estimated using shadow prices.*

Secondary Impacts: Thus far we have confined our attention to a discussion of the direct inputs and outputs of a project, often called primary impacts. Investment also has multiplier effects, arising both from the economic activity generated by the expenditure on goods, services, materials and wages - called backward linkage - and any downstream activity, e.g., processing of outputs, resulting because of the investment (forward linkage). To the extent that these linkage effects mobilise heretofore underemployed resources, they are called secondary benefits. These are generally not attributable benefits in cost-benefit analysis, on the grounds that the expenditure (private or public) which the investment is displacing would also have secondary impacts. While we fully endorse this view in principle, it is true that some projects have more linkage impacts than others, and this difference can be of some significance in an underemployed economy. There would be great difficulty in "netting out" the secondary benefits (these would be negative for those projects which had lower secondary benefits than the expenditure which they displaced would have had). We recommend, therefore, that for those investments which are expected to yield exceptionally beneficial linkage effects, these be shown as a separate display.

We will draw on the economic concepts outlined when we examine arterial and field drainage policies respectively in the next two sections.

III ARTERIAL DRAINAGE

Legal and Administrative Framework

Before the 1945 Arterial Drainage Act was passed, a Commission studied how the government might best intervene on arterial drainage. The Commission came up with the following major recommendations.[9]

> The government should only involve itself in draining entire catchments. A programme covering 586,000 acres was proposed.
>
> The government should bear all the cost of construction.
>
> Beneficiaries should contribute 70 per cent of the assessed improved *annual* value of the lands affected towards the cost of maintenance.[10]
>
> The government should gradually centralise maintenance of all existing drainage schemes in the National Drainage Authority.

The motivation behind the proposed government interventions was clearly the public goods nature of the external benefits involved. Explaining why the state should undertake work which was not sufficiently economic to charge even a portion of construction costs to the beneficiaries, the Commission cited:

> the spin-off effects of greater agricultural prosperity

9. Under the previous programme, sections of a river were drained only after the assent of a majority of the local occupiers. The maximum state grant towards construction was 50 per cent and the full cost of maintenance was borne directly by the local occupiers of benefiting land. This system militated against the undertaking of works to improve outfalls of a river; the benefits accrued to farmers in the upper reaches of the catchment whereas the assent and the finance had to be sought from occupiers in the lower reaches.

10. Valuers survey the catchment and assess the likely improvement in the market value of benefiting land. The annual value (i.e., rental value) is calculated as 5 per cent of the market sale value.

the necessity of channel improvements before private improvements would be worthwhile

the alternative of deteriorating drainage conditions and mounting remedial costs

the indirect benefits to transport, public health, urban areas and sewage outfalls.

Besides such externality arguments, they regarded arterial drainage as an "essential service" whose provision should "not be governed entirely by economic considerations". Indeed, they argued it was a matter of "national pride".

However, this reasoning did not pass without a dissenting voice. The Department of Finance Representative, Mr Hanna, did not accept that the benefits (unestimated) from the proposed programme were sufficient to justify a cost per acre which he noted was almost twice the prevailing price of land. He down-valued all the would-be external effects. He believed better agricultural returns could be had by improving existing dry lands; said the programme offered a "palliative of very limited efficacy for unemployment", and dismissed the argument of indirect benefit, saying that housing and primary education have "infinitely stronger claims upon public monies than any services that would be likely to obtain indirect benefit from arterial drainage". He concluded that adoption of the programme in its entirety would, on the face of it, involve "a dissipation rather than a creation of national wealth". He believed catchments should only be drained where returns commensurate with the cost of construction and maintenance could be obtained: the state should never contribute more than 60 per cent of the construction cost and higher maintenance charges should be levied locally.

The 1945 Act

In the event, the government went even further than recommended by the majority report. The programme of drainage works adopted was twice the acreage of the original proposal. The farmers affected were relieved of maintenance as well as construction costs. Responsibility for all maintenance was to be gradually centralised in the Office of Public Works

and the charge for it levied on the county-at-large.[11] The OPW were given the full powers of initiating proposals. They immediately drew up a programme of priorities.

They estimated that, in all, about 1.2 million acres of flood-damaged land depended on arterial drainage for relief. The programme consisted of 28 major catchments (each over 100,000 acres in total area) and 30 minor catchments throughout the state. They were ranked in the order in which they were to be carried out. The selection was based on petitions and survey work under the previous (1925) Act, supplemented by the County Surveyor's impression of local need and limited inspection of catchments. Rough costings were made. The ranking was based on the severity of the drainage problem, but the extent of existing preparatory work, the absence of problems of design or compensations, and the costs per acre of improvement works were also considered. The emphasis was on handling the drainage problems subject to certain constraints rather than applying economic criteria in the selection and ordering of projects. This original ranking has been adhered to ever since, with rare exceptions being made where a catchment has been deferred on economic grounds.

Under the Act, the Office of Public Works are charged with the task of improving agricultural lands affected by flooding. Protection of environmental interests is not their explicit responsibility. They enjoy wide powers of entry, interference and acquisition of rights (subject to compensation for damage). Their proposals must first go on display, and affected owners are notified. Objections from any quarter have to be considered, but there is no specific court of appeal against a decision to go ahead in the face of objections, although aggrieved landowners have (very occasionally) appealed successfully to the general courts. The Commissioners also enjoy an exemption from the Fishery Acts, the Planning Acts and the Water Management Acts.

While the OPW have considerable legal powers to ignore other interests, from the outset they have made attempts in design and execution of schemes to minimise damage to fish-

11. Responsibility for maintenance has not, in fact, been centralised and the strictures of the Commission on the lack of proper maintenance on pre-1945 schemes probably still apply in some areas.

eries. On recent schemes efforts have been made to accommodate a wider body of interests. A committee representing environmental interests assesses the likely damage in advance. In execution, the OPW try to avoid damage where this is not in fundamental conflict with drainage, or failing that, to minimise the damage by modification or remedial works.

However, the balance of power is tipped against environmental interests at a number of points:

(i) Responsibility for environmental protection is scattered among a number of independent bodies. The onus is on them to alert the OPW to dangers, and demonstrate their seriousness. It is up to them to procure landholders' agreement to conservation measures or make statutory orders of enforcement.

(ii) Scientifically testable data in support of a case for conservation is only slowly being assembled. Even when available it is hard to evaluate against clear-cut farming benefits of drainage.[12]

(iii) The property-rights to the environment rest with landowners, so environmental interests would typically have to compensate for the benefits forgone even though the drainage is financed entirely by the community.[13]

Cost-Benefit Appraisal

Thirty years after Mr Hanna's dissenting comments, the Department of Finance Appraisal Team (1968) returned to the same theme. They suggested that the cost of drainage exceeded the improved market value of benefiting lands. Indeed, in many cases costs exceeded the full post-drainage value of these lands.[14] They recommended halting work on the 1945 programme, and only proceeding after a full cost-benefit appraisal of the merits of proposed schemes. This was initiated in 1970 by the Office of Public Works. A steering group comprising nine members drawn from the Department of Finance (3) and Agriculture (2),

12. Under EEC auspices a French consultant - M. Mercier - is now undertaking an environmental impact study of drainage in Ireland. Hopefully his work will help fill this gap.
13. One exception to this is where a Local Authority declares an area to be of special natural significance, and protects it by an Amenity order. This is very rare.
14. This Report was not published, but is cited in the Maigue Study.

the Office of Public Works (2) and An Foras Talúntais (2) developed the analytical procedures to be followed. Hereafter, these are referred to as the OPW Steering Group procedures.

In assessing drainage schemes, the OPW treat the increase in landholders income as the primary benefit. Secondary benefits are derived from the spin-off of employment and the incidental benefits of drainage to the non-farm community. The estimation of the gross benefits is based on a projection of the response of output to the scheme and of the gross profit margin earned as a result. The uncertainty surrounding these projections is handled by examining the results for more pessimistic outcomes.

Against the benefits are set the direct costs of arterial drainage, the cost of follow-up field drainage and the investment in livestock and buildings associated with the output targets. Because of evaluation problems, no direct estimate is made of the damage done to the environment. Instead, environmental impact reports are presented. Only in the case of fishing is an effort made to cost the measures taken to adapt in the post-drainage situation.

The costs and benefits are set out over a fifty-year time horizon in constant prices and then discounted at a real rate of three and a half per cent per annum. Other discount rates are used experimentally to see if they make material difference to the appraisal.

Cost of Drainage

In Section I it was shown that real spending per acre drained increased significantly since the 'fifties. The costings at design stage were much higher on recent catchments; in addition, on the more recent projects actual spending has been exceeding the design budget.

The costings for individual catchments are set out in Appendix Table 4 at constant 1980 building prices. The budgeted costs are shown and compared with the actual outturn. The data are summarised in Table 4. A number of points emerge quite clearly.

Budgeted costs per acre on schemes started since 1960 were 25 per cent dearer than those incurred on previous schemes. If

the very low cost Brosna scheme (1948–55) is excluded, we find that budgeted costs in the 1960s and 1970s exceed those of the 1950s by eight and seven per cent respectively.
On several schemes the OPW did not manage to stay within the construction cost budgeted at design stage. Overall, the bill picked up by the taxpayer overran budget by 11 per cent. Drainage conditions may have proved more difficult than anticipated, or unexpected delays may have been encountered. Delays not only involve the incurrance of direct costs, but also cause an escalation indirectly in the form of extra maintenance costs. Delays can be caused by budgetary rationing undertaken to serve macro-economic objectives, in addition to those necessitated by logistical problems. The schemes initiated since 1960 on average incurred a percentage budget overrun three times that of earlier schemes. The combination of high design cost and overrun result in actual costs on later schemes being 45 per cent dearer than those started in the 'fifties.
In smaller catchments, design costs have proved slightly cheaper and budget overruns have been much more effectively contained.

Table 4: *Costings in catchments completed*

	Cost per acre of agricultural land drained (£ 1980)			
	Budgeted at design stage		*Percentage overrun of budget*	
Catchments	*Started before 1960*	*Started later*	*Started before 1960*	*Started later*
Major	362.8	458.8	+8.9	+31.7
Minor	377.4	401.0	+3.3	+ 4.5
Total	363.6	449.8	+8.6	+27.9

Note: The data show simple averages, not the mean cost from different catchments.
Sources and Notes: As for Appendix Table 4.

At present, work is proposed or in progress on four major catchments and one minor catchment. The cost at design stage on these (not shown) is four per cent dearer than those started after 1960 (shown in the second column of Table 4). It is not yet

clear how spending on schemes in progress is faring against budget. If overrun is a strong likelihood, an explicit "unforeseen construction cost" provision should, in future, be added to costs to cover the contingency, as is done in the US. In the Estimates Book, the OPW presents an estimate of total design cost and the spending to date on each scheme in progress. However, it is not possible to glean from the figures presented whether spending is overrunning the budget. This deficiency could be simply remedied, and it would set a useful example for other areas of capital spending.

Direct Benefits of Drainage

Under the 1945 Act, the OPW are obliged to make an "Award" on completion of each scheme. The Award should state:

(a) The works done and date completed.
(b) The area of land benefiting in each county affected.
(c) The pre-drainage annual value of those lands and the increase in the annual value as a result of the drainage works.

The Award should be enrolled in the Central Office of the High Court and a copy sent to the Council of every county affected. So far this has not been done for any of the schemes completed. Without this information it is more difficult to assess the economic impact of drainage. However, some projections made at the design stage have been kindly released by the OPW.

Enhanced Land Value Under 1945 Act

One crude measure of the gains from drainage is the increased market value of farm land expected to benefit from drainage. This is presented in Appendix Table 5 for individual catchments and summarised in Table 5. Valuation made in different years have all been revalued at 1980 land prices.

Several points stand out from these tables:

Averaging over all completed catchments, arterial drainage added £564 (at 1980 prices) to a pre-drainage value of £816 per acre - a gain of almost 70 per cent. Land in 1980 was fetching an average price of £1,500, so drainage gave a

benefit equivalent to about one-third of an acre of land.

The gain in land value from drainage has been rapidly dwindling. Schemes started before 1960 increased the pre-drainage value of land by almost 80 per cent or £700 at 1980 land prices. However, on the later schemes the increase in pre-draiange land value was only a little over 50 per cent or £400 at 1980 land prices. This decline reflects the movement to catchments of lower priority.

The projected benefit in land value from schemes in progress or proposed continues the downward drift. The pre-drainage value of land in these is expected to increase by only 45 per cent or £350.

Table 5: *Improved market value of agricultural land benefiting from arterial drainage*

	Improved market value of land	
	As a proportion of its pre-drainage value %	*Per acre drained £ 1980*
Started before 1960	78.5	721
Started later	53.3	388
Total completed	69.1	564
In progress	43.1	361
Proposed	52.0	224

Notes and Sources: As for Appendix Table 5.

In Table 5 it can be seen that the improved market value of land as a proportion of its pre-drainage value has declined over time. This indicates that the corresponding reduction in the absolute values is not solely a product of a changing base value.

The improved land value can be compared with the outlay on arterial construction work. This is done in Appendix Table 5 (Column 3) where both land and construction costs have all been revalued at 1980 prices. It is summarised in the first column of Table 6.

Table 6: *Improved market value of drained land and construction cost of arterial drainage compared*

	Ratio of improved land value to construciton cost				
	At 1980 prices	*At 1972 prices*	*At 1978 prices*	*At 1979 prices*	*At average prices prevailing 1950-1980*
Started before 1960	1.859	1.344	2.293	3.582	1.610
Started later	0.675	0.488	0.833	1.300	0.585
Total completed	1.184	0.856	1.460	2.281	1.025
In progress	0.786	0.568	0.969	1.514	0.680
Proposed	0.409	0.296	0.505	0.789	0.355

Notes and Sources: As for Appendix Table 5.

The table supports the hypothesis that diminishing returns have set into outlays on construction. On the early schemes the improved value of land was almost twice the outlay on construction. On later schemes it has only covered two-thirds of the outlay. The picture seems to be a little better on schemes in progress. However, the comparison here is with budgeted costs. If they repeat the 30 per cent budget overrun that characterised schemes recently completed, the proportion of costs covered will fall to 60 per cent. On proposed schemes the picture is less promising with only 40 per cent of costs covered before any allowance is made for budget overruns.

There are several weaknesses in using improved land values as the absolute measure of return on investment in drainage. They will be discussed later. Not least among them is the extreme volatility of land prices compared to construction costs. The effect is illustrated in Columns 2-4 of Table 6, where different base years are chosen for comparison. Although the evidence of diminishing returns is unaltered, the proportion of costs covered changes radically. For example, looking at completed catchments started since the 'fifties, we find that valued at pre-EEC land and construction prices in 1972, improved land value covered 49 per cent of costs, at 1978 prices it covered 83 per cent of costs, at 1979 prices 130 per cent and at 1980 prices it was back to 68 per cent of costs. If average prices prevailing in 1950-1980

are used to remove year-to-year volatility improved land covers 59 per cent of costs.

Which is the "correct" relative price of land is a difficult question. Since joining the EEC there has been a revolution in land prices. Between 1972 and 1979 land prices experienced uninterrupted growth at an average rate of 36 per cent per annum. The growth in 1979 was a staggering 52 per cent. This bore no relationship to actual profitability performance. Family farm income per acre declined as a proportion of land prices from eight per cent in 1972 to four per cent in 1978, two and one-quarter per cent in 1979, recovering to three and one-quarter per cent in 1980.[15] The normal ratio between the annual value of land and its market price used by the OPW is five per cent. This would suggest that 1979 was an abnormal speculative bubble in the land market. It is, therefore, disconcerting to find that even at 1979 prices improved land values do not cover construction costs in the catchments now at proposal stage. Indeed using land prices in years after a catchment is drained is putting the project in a more favourable light than it enjoyed at the time it was undertaken.

If we take 1978 as the year closest to normality in the land market, then it emerges from Table 6 that schemes started since the 'fifties or in the pipeline are not capable of covering construction costs by the improved market value of land. This comparison ignores the cost of maintenance. Maintenance typically runs at about one and one half per cent of construction cost. Capitalised over a horizon of 20 years it adds a further 20 per cent onto the cost of construction. Making this allowance in Table 6 would indicate that the completed drainage schemes started since 1960 cover only 70 per cent of the total cost of construction and maintenance.

It is illuminating to consider how the cost of construction and capitalised maintenance relate to the *total* post-drainage value of land. Using 1978 as base, we find that drainage provided flood free land at a cost equal to 23 per cent of its final value on early schemes rising to 44 per cent on later schemes. On schemes at the posposal stage it has reached 81 per cent.

15. This measure makes no allowance for paying family labour. If such were deducted, the return to capital employed would commonly be negative.

Enhanced Land Value Under Previous Acts

We can compare performance under the 1945 Act with earlier Drainage Acts by the ratio of improved land value per acre to construction costs per acre. This is done in the first column of Table 7 at current prices. It can be seen that the projects undertaken under the aegis of the 1945 Act are giving lower returns than those undertaken earlier. The proper comparison at constant 1978 prices could only be done approximately (shown in Column 2); these data reinforce the pattern indicated by the analysis using current prices.

The earlier Acts were commercial in their approach. Apart from the Owenmore and Barrow, they did not drain the entire catchment, but concentrated on bottlenecks where returns were high. A scheme went ahead only if the occupiers consented and made a financial contribution. It can be seen in Table 7 that where higher contributions from occupiers were required, returns were also higher.

Table 7: *Performance under drainage acts*

	Ratio of improved market value of benefiting land to construction costs				*Proportion of cost borne by occupier*
	At current prices		*At constant 1978 prices*		*per cent*
1842 Act	0.768		NA		48.1
1863 Act	0.782		NA		93.6
1925 Act	0.471		3.92		23.1
1928 Act	1.592		13.14		67.4
Owenmore and Barrow (1926)	0.201		1.62		12.5
1945 Act (I)	0.306	0.190	2.29	1.46	0.0
1945 Act (II)	0.127		0.83		0.0

Notes:

(i) Column 2 presents estimates based on approximate price data.

(ii) No land price data are available for the 19th century.

(iii) The 1928 Act only tackled very small jobs, which undoubtedly contributed to good performance.

(iv) 1945 Act (I) applies to those schemes undertaken before 1960, while 1945 Act (II) refers to all schemes initiated subsequent to 1960.

Rank Order of Schemes

The ratio of improved land value to construction cost in Appendix Table 5 provides a ranking of completed catchments by return over cost. It is striking how close this ranking is to the order in which the schemes were, in fact, commenced. The only deviation was that on merit, minor schemes should have been started earlier.

Amongst the catchments in progress we can only rank on the basis of budgeted costs. Once again it is clear that the order of commencement has followed the ranking by return over cost. The order of commencement has closely followed the priority list established in 1945, except for three major and three minor catchments that were deferred on economic grounds. It is a tribute to Dr. Coady, Chief Engineer in the OPW, who drew up this list from sketchy information, to find how closely his priorities conformed with the results realised.

Examination of the improved market value of flood-damaged land does not allow us to reject the hypothesis that diminishing returns have set in. Indeed, with the improved value covering only 70 per cent of total costs on recent schemes it would suggest that the drainage programme has already gone too far. We must now look at the reliability of this measure of the returns to drainage and examine whether applying the broader cost-benefit approach would alter our conclusions.

Limitations of the Land Value Measure

The improved market value of lands is not a wholly satisfactory measure of the benefits of drainage. It omits all indirect benefits. Among these are employment for workers who would be idle in the absence of the project, and flood relief for the non-farm community. Indeed, it is also challenged as a measure of the direct benefits to the farm community. Two objections can be levelled against it on this score: first, it overlooks benefits accruing to factors that combine with land on the farm; and second it ignores far-off returns that are important to the community. These incline it to understate the full farm

benefits as follows:

(i) In a world of perfect foresight, the market value of land will equal the present value of future net income where all input factors save land are appropriately priced. An increase in land value will only capture the full benefits of the improvement achieved by drainage if all factors that combine with land (labour, capital and management) had been fully employed before drainage. In that event, the extra income paid to these factors can be ignored because it only balances the opportunity cost of drawing them in from their previous activity. However, the OPW contend that the extra man-hours and machine-hours have no opportunity cost for the farmer and so the earnings going to these factors are true benefits to be added that will not be captured by the land price improvement.

(ii) When putting a value on land, the market is likely to consider the income yield from the land over a comparatively short time horizon and discount heavily. However, the community may value far-off returns more highly, i.e., the rate of time discount of the community may be lower than that of private individuals.

While these theoretical objections suggest the true benefits are understated, it is an observed fact that the market value of land is far higher than is justified by realised annual returns in farming when the other factors that combine with land (principally the farmer's own labour) are costed. Many believe that the price farmers will pay for land in the market takes little account of the cost of co-operating factors, which the farmer may regard as marginal to his existing operations. If this is so this destroys the first argument above and the land value includes the full benefits. It is also thought that the price paid for land includes a reckoning that land will appreciate in value faster than general prices. This tends to undermine the second argument above. On balance, we would expect that the land value is not too wide of the mark as a measure of drainage benefits.

A further difficulty with the land value proxy for the benefit of drainage arises when re-valuing to different base year prices. Ideally we would like to have separate price indices for land "with" and "without" drainage and we could directly

recalculate the increment. This is not possible. The options are to inflate by a product price index or by the much more rapidly growing land price index.[16] Land prices are influenced by many supply and demand factors that may have no bearing on the incremental gains from drainage. For example, as a fixed factor, land is able to appropriate part of the returns to technical advances in farming which may have no effect on the value of draining. Similarly, if land is expected to give more effective protection against inflation than other assets, this expectation will be capitalised into market price. Again this may have no bearing on the incremental gains from draining.

The Cost-Benefit Assessment of Direct Effects

The OPW has done cost-benefit analysis on four catchments so far – the Maigue, the Corrib-Mask, the Boyle and the Bonet. Work is in progress in the first two of these, and the other two are due to be started shortly. This analysis makes a projection of the boost in future farm output from drained land. The projected stream of earnings is then calculated and discounted to yield its present value.

In computing earnings, the OPW use what is known as "gross margins". This measures the value of sales minus costs such as feed and fertilizer which are directly attributable to a certain line of production. The OPW also take account of on-farm investment in buildings, stock and field drainage. However, they ignore other items of overhead costs that will grow along with output from reclaimed land: the interest, depreciation and operating expenses of machinery; hired labour and the general upkeep of land. They also ignore the cost of the farmers' own labour.

Land Values and Future Earnings Compared

In the first column of Table 8, the rival measures of farm benefit are compared, and each in turn is set against the costs of drainage. The improved market value of land "captures" only a fraction of the calculated present value of future earnings. This is not surprising, since land value is (in theory) derived as the present value of net returns accruing after all other costs

16. Land prices grew at roughly twice the annual rate of consumer prices in 1950–1980 as can be seen in Appendix Table 8, so this is an issue of some practical importance.

(including labour) have been deducted. However, future earnings include a return to labour and management in addition to the return to land *per se*. At prices current when the original valuations were made, improved land value covered only 16 per cent of the present discounted value of net income. The fraction is sensitive to re-valuation of earnings and land values to common base year prices. land prices have generally grown much faster than farm profitability (see Appendix Tables 8 and 9), so that the fraction tends to be larger if a recent base year is used. In 1979 a boom in land prices accompanied a slump in profitability so that the fraction rose to a peak of 41 per cent. However, the fall in land prices in 1980 saw it drop back to 27 per cent. The contrast between the two measures of benefit is even more striking when compared with costs. The improved market value of land covers less than half the costs of drainage. However, the estimate or present worth of future earnings covers cost twice over.

Table 8: *Improved market value of land and present discounted value (PDV) of future net income compared*

	Ratio of improved land value to PDV of net income	*Ratio to costs*[1] *of drainage of*	
		Improved land	*PDV of net income*
	per cent	*Value*	
At current prices	15.8	0.456	2.881
At constant (1972) prices	10.2	0.329	3.220
At constant (1979) prices	18.0	0.543	3.022
At constant (1980) prices	27.4	0.494	1.801

1. The present discounted value of construction and maintenance less saved maintenance.
Source: As for Appendix Table 6.

In the four analyses undertaken to date, the following asusmptions have been used in the calculation of the farm

benefits:

A fifty-year horizon and three and one half per cent real rate of discount were used.

The base year real profit from livestock was up to 48 per cent higher than actually prevailed in 1980, and was projected to grow further at one-two per cent per annum in real terms.

Stocking rates per acre were projected to grow at one to one and one half per cent per annum.

Nine-tenths of farmers were expected to respond to the opportunity presented by arterial drainage.

Responding farmers were expected to reap the same proportion of production potential from reclaimed land as they did on existing good land.

With hindsight the productivity assumptions now appear to be rather generous. The income assumptions were a product of the optimistic times when farming was adjusting to EEC farm product price levels.

It is difficult to know what is the proper base to use for farm earnings (Table 9). The base years used in these studies (1973 and 1978) were both exceptionally profitable years as is clearly shown by graphing the real value of gross margins in beef and dairying. (See Graph 3 and Appendix Table 9.) It is to be hoped that 1980 proves to be an unusual trough, and that 1977 (also used in Table 8) is a "typical" level of profitability that might be used. However, this optimism is not shared by all; some would foresee a return to the experience of the first half of the century when real farm profitability fell by one per cent per annum. The other assumptions are also questionable in the poorer farm climate now faced. Growth in stocking rates are unlikely to reach even one per cent per annum and the degree of response from farmers may also be dampened.

Sensitivity of Returns

The effect of modifying some of these asusmptions on both the fraction of projected future earnings captured by land values and the benefit cost ratios is shown in Appendix Table 6 and summarised in Table 9. As less generous assumptions are made the benefit-cost ratio drops and the land value measure begins to

Graph 3: *Gross margins per livestock unit at constant (1980) prices.*

Source: Appendix Table 9.

move closer to the direct measure of future earnings. If 1980 profitability is used and low growth assumptions are made, there is only an eight per cent excess of benefits over costs on the four catchments together, and two of the four catchments fail to give a positive return over cost.

Table 9: *Sensitivity of present discounted value (PDV) of future income*

	Ratio of improved land value to PDV of farm income	*Ratio of PDV of farm revenue to total investment*
Original analysis	15.8	2.024
1977 profitability	18.0	2.128
1977 profitability and low growth	28.1	1.567
1980 profitability	27.4	1.449
1980 profitability and low growth	43.9	1.076

Note: The benefit-cost ratio used here is slightly different from that used in Table 8 in that total revenue is compared to total investment rather than net earnings to investment in drainage alone. The former is a more appropriate and more exacting test.

Source: Appendix Table 9.

As described earlier, the OPW ignore certain items of overhead cost that do vary along with output; they also ignore the cost of the farmer's own labour. The former items amounted to 20 per cent of gross margins in farming overall in 1980. If Table 9 were modified to take account of these, the land value would get closer to computed income, and the benefit-cost ratios would deteriorate. Indeed, the benefits fall short of costs under the most severe assumptions above; three of the four catchments fail the test. It hardly seems credible that the farmer's own labour has a zero opportunity cost. Any allowance for cost on this score would alter the results in Table 9 quite dramatically, and land value would no longer be much wide of the mark in measuring full farm benefits.

The present net worth is also sensitive to variation in the

discount rate and in the time horizon. A shorter time horizon or higher discount rate reduce the weight given to far-off years. Typically full benefits are then accruing but only small costs are being incurred, so benefit-cost ratios deteriorate. Some illustrative cases are shown in Table 10 at constant 1980 prices under both original and low growth assumptions. For example, in column one we find that even under optimistic growth assumptions, the benefit-cost ratio turns around if a seven per cent discount rate is used. Moreover, the gap narrows between improved market value of land (not shown) and the present value of net farm income. Indeed, under the low growth assumption the improved land value exceeds net farm income when a 10 per cent discount rate is used.

Table 10: *Sensitivity of the ratio of benefits to costs*

Horizon years	*Discount per cent*	*Ratio of PDV of farm revenue to total investment*	
		1980 profitability	*1980 profitability and low growth*
50	3½	1.449	1.076
35	3½	1.216	0.968
50	5	1.222	0.923
50	7	0.972	0.763
50	10	0.720	0.593

Note: The calculations here are illustrative based on the simple assumptions that construction costs are incurred in the first year; farm revenues, farm costs and arterial maintenance are spread evenly over the whole horizon.
Notes and Sources: As for Appendix Table 6.

Individual Catchments

The examination of individual catchments in Appendix Table 6 also yields some important lessons. The fraction of the present value of net farm income captured by land values varies quite dramatically among catchments. This is noticeable at the time of original valuation, but is greatly magnified by re-valuation to a common base-year. Land values captured a higher proportion in the Maigue (Limerick-Tipperary) than in the other three catchments, all situated in Connaught. As a

result, the ranking of catchments by the ratio of improved land values to cost does not conform with the estimated benefit to cost ratio.[17]

The absolute benefit-cost of catchments is sensitive to the base-year of valuation and various other assumptions, as we have already seen in Tables 8 and 9. However, the ranking of catchments is also affected. A common basis of comparison must, therefore, be carefully chosen to avoid misleading conclusions.

Appendix 6 also reveals that altering the base-year of valuation and other assumptions can alter the ranking of projects as well as their overall worth.

To summarise, the evidence suggests that the improved market value of drained land may understate the likely farm benefits. However, the understatement may not be large. In particular, it is difficult to determine the extent without actual evidence on the degree of farmers' response to the opportunity offered by arterial drainage. On the other hand, land values are inflating faster than the true benefit. A direct measure of likely farm benefits is preferred but it must be founded more firmly on tested data and consistently applied across different catchments (see Section V for further discussion).

"Secondary" Effects

The OPW have avoided some of the worst pitfalls in the valuing of secondary benefits. They do not attempt to include among the benefits the "multiplier" gains in employment as incomes generated by drainage construction percolate through the economy. In their first study they included the domestic value added of goods and services as a benefit. Implicitly, this assumed that domestic inputs used in drainage has no opportunity cost. Any investment that did not use imports could seem worthwhile on that test. Fortunately, this assumption has been dropped.

17. Use of land values to rank projects might give a systematic bias against certain regions, because there appears to be significant regional variation in the relationship between farm income and land value. In 1973, for example, family farm income constituted 4.5 per cent of the land price in Leinster, 4.7 per cent in Ulster (3 counties), 6.0 per cent in Munster and 6.5 per cent in Connaught. Ranking projects by land value would seem biased against Connaught. However, these differences may reflect a larger input of farmer labour in Munster and Connaught.

The only secondary benefits now valued are:

The benefit of employing persons on the project who would otherwise be idle.

The benefit of training imparted.

The benefit of drainage to bogs, roads and built-up areas.

The benefit of new bridges and culverts.

The cost of fishing opportunities forgone is estimated and presented as a secondary cost.

The estimated secondary effects for four catchments are presented in Appendix Table 7. The impact on the benefit-cost ratios is presented in Table 11. The benefit resulting from the shadow pricing of labour comprises 93 per cent of all secondary benefits. We argue later that the OPW should not include shadow priced labour as a benefit. We earlier outlined an approach to the inclusion of environmental impacts in analyses.

Table 11: *Impact of secondary effects on the gross benefit to cost ratio on four catchments*

	Ratio of benefits to costs	
	Primary (i.e., farm)	*Primary and secondary*
Original analysis	2.024	2.322
1977 profitability	2.128	2.428
1977 profitability and low growth	1.567	1.907
1980 profitability	1.229	1.749
1980 profitability and low growth	1.076	1.410

Source: Office of Public Works.

We feel that the beneficial impacts of drainage on bogs, roads and built-up areas, and the provision of new bridges and culverts, being in a sense unique to drainage investment, are attributable benefits. However, we feel that they should be included with primary benefits. The distinction between primary and secondary benefits and costs should be dropped.

The inclusion of secondary effects has had little effect on the ranking of catchments. This is hardly surprising since the employment effect of the construction work dwarfs all the other secondary impacts measured, and this is similar across projects.

IV FIELD DRAINAGE

State Support Schemes and Their Cost

Land Project

The rate of support has differed under the various schemes. Under the land project the farmers had the option of:

(a) Carrying out the work themselves and receiving a 2/3 grant[18] of the cost up to a specified maximum level of assistance per acre.
(b) Letting the state contractor do the work and paying a 2/5 contribution up to a specified maximum payment per acre.

There was a certain asymmetry in these options which farmers proved quick to exploit. The state's contribution was tightly controlled under (a) and was eroded by inflation, but it was completely open-ended under (b). Farmers reacted by doing the simpler jobs themselves, often more cheaply than the standard cost used by the government for deciding its grant, while the state contractor was "awarded" the awkward projects. Not surprisingly, the government soon decided that it was not a suitable agent for direct work and withdrew the option in 1958.

Table 12 shows the cost of state support. As one would expect, the state contractor option proved more than twice as expensive per acre as the grant option. However, in combination the two options worked out costing the state £91 per acre (in constant £1980) in the 'fifties, which proved cheaper than sole reliance on the grant option in the 'sixties. Indeed Graph 2 shows that *grants* per acre rose during the 'fifties and stayed on a high plane throughout the 'sixties. It fell in the 'seventies, because the grant

18. Grants and contributions were based on a national standard of approved costings for each element in a job. The implicit maximum total cost per acre on which ceilings were based was £30 in 1949–55, £45 in 1955–65 and £67.5 in 1965–74 (with a £15 higher maximum permitted in the West from 1965) all at current prices.

ceiling was never relaxed between 1965–77 even though inflation reduced its real per acre value.

Table 12: *Cost of state support under various schemes*

Scheme	*Form of support*	*Period of operation*	(000) *Acres benefiting*		(£ 1980) *Cost per acre*	
Land project	State contractor option	1950–58	149.3 818.9	968.2	209.0 69.7	91.2
	Grant option	1950–59				
	Grant option	1960–69	935.6		97.9	
	Grant option	1970–77	651.4		83.8	
	Grant option	1950–77	2405.9		85.6	
Farm modernisation	Grant	1974–80	468.6		86.4	
Western drainage	Grant	1979–80	73.8		133.2	

Expenditure has been deflated by the Consumer Price Index.
Source: Department of Agriculture.

EEC Backed Schemes

Under EEC directives the rate of grant support available discriminates among farmers and among investments. The pattern of state grants is set out in Table 13. The following economic rationale can be suggested to "explain" this pattern: The grant for drainage by commercial farmers may imply the degree to which farmers underestimate the merits of drainage either through short-sightedness or because some of the benefits accrue beyond the farm gate. This grant is larger than that for short-life investments whose pay-off is more fully appreciated. Development farmers are those who are undertaking a farm plan designed to raise their income to commercial (non-agricultural) levels over a period of six years. The wider scope of grants and the premium rate available to them can be justified by their poorer access to capital. "Other" farmers and western farmers also enjoy a premium rate of grant. Here, income distribution motives and recognition of their scanty opportunities for employment outside farming would be at work.

Table 13: *The percentage rate of grant assistance available under the farm modernisation and western drainage schemes*

Type of investment	*Type of farmer*[3] *Commercial farmers*	*Development farmers*[4]	*Other farmers*	*All western farmers*
Drainage and reclamation	35	45	45	70
Buildings and fixed assets	15	25	25	40
Mobile equipment	-	-	-	2
Purchase of extra stock	-	10[1]	-	2
Fertilisers	-	-	-	-

Notes: A dressing of fertiliser is included as one of the grant assisted elements in a drainage and reclamation job, but there is no general scheme of fertiliser subsidies.

1. Subject to condition that meat production becomes the main source of sales revenue by end of a plan period.
2. Western development farmers get grants for equipment and stock.
3. Grants generally apply to persons with farming as their principal occupation, but the western drainage grant applies to all. Part-time farmers will get assistance only if their combined income from all sources is below comparable incomes outside farming.
4. Under the FMS, the EEC contributes one-quarter of grants paid to development farmers. However, it puts a ceiling of 30 per cent on the maximum proportional rate of grant eligible for EEC support. In view of the higher rate of grant offered by the Irish government for drainage, the EEC contribution effectively falls to less than one-sixth.

The EEC has generally held the view that production aids should only go to enterprises that are potentially commercial, because otherwise they serve to aggravate surplus production. Indeed under the Farming Modernisation Scheme (FMS) the EEC only contributes towards grants for "development" farmers.

The initial purpose of the FMS was to direct aid primarily towards development farmers, comprising 22 per cent of the total. In practice it has not operated quite like that. Only 34 per cent of the work supported has been on development farms. The majority (56 per cent) has been on farms in the "other" category. One result has been that the EEC contribution towards the cost of FMS grants has been very small. In the case of field drainage the EEC contributed less than five per cent of grants paid. The average rate of grant support for field drainage worked out at 49 per cent of approved costs. Nominally, this is a lower rate of grant than was available under the Land Project which came to 2/3 of cost. However, the grant ceiling on

support for drainage has been dropped and replaced by a ceiling on the total amount of grant-aided investment per labour unit on the farm. This has not yet proved a constraint on drainage. Table 12 shows that per acre support for drainage under the FMS has, in practice, been higher than it was under the land project.

The EEC contribution to the Western Drainage Scheme (WDS) is more generous. It contributes half of the grants paid up to a ceiling for the total grant paid of £160 per acre. With both the FMS and WDS operating, the EEC contribution came to almost 20 per cent of all grants paid for field drainage in 1980.

The WDS costs the state (including EEC) 54p more in every pound than the FMS.* About 44p of this is due to the higher rate of grant and 10p due to more costly drainage works. The introduction of the WDS reduced the cost of drainage work to the farmer by 40 per cent. Interestingly, it has induced just over 40 per cent increase in the amount of land treated by the qualifying counties in the first two years of its operation. Drainage appears to be price responsive. However, under earlier schemes the take-up of drainage had been proportionately lower in many of the western counties, so this result might not be reproduced nationally.[19]

Achievement in Field Drainage

Progress in land improvement since 1945 has been impressive in quantitative terms. Just over half of the six million acres thought to be in need of drainage have been tackled. However, the economic measure of achievement is the return from resources invested. The only evidence on this question comes from the land project Survey Team (1968). Their sample was small (70 drainage jobs) but their methods were rigorous and their findings are still instructive, in spite of the fact that it is now thirteen years since the study was done.

*133.2 86.4 = 1.54.

19. The area of land improved under earlier schemes averaged 26.8 per cent of all farm land in the state; in counties affected by the WDS, it averaged 20.4 per cent. In some it was far lower, e.g., Leitrim (12.9 per cent), Clare (15.0 per cent), Roscommon (15.2 per cent) and Longford (17.4 per cent).

Survey Team Appraisal

Appraising this on-farm investment, the Team preferred to apply a commercial standard rather than the broader cost-benefit approach. They followed the discounted cash flow (present net worth) method. The assumptions built into this calculation were much more demanding than those used in studies of arterial drainage:

A real discount rate of 7 per cent was used over the average 36 years life of schemes.

Output was estimated five years after the drainage job was approved. The improvement achieved by then was assumed to obtain for the entire life of the scheme.

The income generated from improved output was calculated using the relatively low profit margins prevailing in 1968 (see Table 15).

These margins were also assumed to obtain for the entire life of the scheme.

The on-farm labour time and machinery needed to produce the extra output were costed and included.

Their results are summarised in Table 14. Overall, field drainage proved very worthwhile. It gave a simple pay back to investment inside five years and a discounted cash flow over its lifetime of more than twice the money invested. However, the lessons of the study come from its findings on the variability of performance among schemes and the availability of alternatives. The following striking results were revealed:

37 per cent of the schemes did not cover their costs, and 16 per cent did not even cover half the costs.

14 per cent of the schemes were not worthwhile even if farmers had fully exploited the improved potential of their land.

Half of the farmers had cheaper alternative methods[20] of achieving the same increase in income.

20. The alternatives primarily consisted of using the existing land on the farm more effectively through such methods as increased fertiliser use and better farming practices.

Table 14: *Return on investment in field drainage and alternatives*

	Increment in actual income £/acre (1968)	*Cost of land drainage £/acre* (1968)	*Discounted cash flow (DCF) total costs*	*Annual income as % of potential*	*Proportion with a cheaper alternative* (%)
Western Cos.	5.36	46.82	1.222	65.2	58
Mid-south Cos.	5.75	46.28	1.108	53.4	67
South-east	8.69	38.80	2.325	83.6	43
North-east and midland	9.96	35.31	2.887	81.4	32
State	8.70	38.60	2.320	76.8	50

Source: Survey Team (1968).

Notes:

(i) Income is measured net of direct (seed, feed, fertiliser etc.) costs and extra labour time valued at agricultural minimum wage rates.

(ii) Costs of land drainage include both farmer and government contributions to the cost of the drainage job and a dressing of lime and fertiliser applied to the drained land.

(iii) Total costs include government administration costs (an extra 8½ per cent) and associated stock and machinery investment (an extra 17 per cent on average) over and above land drainage cost.

(iv) The average life of drainage jobs varied from 21 years in the Mid-South to 43 years in the North-east and midlands. This difference in life span does not have very dramatic effects on the DCF-Cost Ratio, and it accounts for only a small part of the observed regional differences in this ratio.

(v) The Survey was not country-wide. The regions were western (Mayo, Leitrim, Donegal, West-Cork); Mid-south (Limerick, East-Cork, Tipperary, Kilkenny); South-east (Wexford, Carlow, Laois, Offaly, Wicklow); North-east and midlands (Louth, Meath, Westmeath, Roscommon, Monaghan).

An interesting fact about the alternative methods was that although they worked out £20 (35 per cent) per acre cheaper on average than drainage (1968 prices), the state grant of about £27 (58 per cent) per acre significantly altered the economics of investment for farmers. In fact, for 30 per cent of the farmers with a cheaper alternative, drainage was financially more attractive to them because of the higher grant support for drainage. Many farmers were responding rationally to the incentives presented to them.

The data also present some very interesting regional aspects of the scheme. The situation in the western counties is particularly worthy of note in the light of the present drainage scheme. In the

west the results show:

The lowest returns per acre to drainage.

The highest costs of draining.

More than half the schemes fail to cover full costs.

A cheaper alternative is available in 58 per cent of the cases.

That there is more difficulty in realising the full potential of drained lands.

Given these results, the lower take-up of drainage grants in the west is not surprising.

Relevance in the Eighties

Since 1968 it is thought that many farmers have developed more commercial attitudes. However, the gross margins - gross revenue less direct costs - in all major farm enterprises have fallen since then. The position in dairying and cattle - the most common uses of drained land - is shown in Table 15 (full details in Appendix 9). Gross margins in these enterprises is down one-third in real terms since 1968. Farmers have also intensified their use of purchased inputs and capital so that the profits share in this output has been squeezed. The effect of higher use of purchased inputs alone is shown in Table 15. If interest, depreciation and operating expense of capital were deducted from gross margins the deterioration in returns per livestock unit would be more marked. We conclude that the net returns to investment in farming are probably less attractive today than they were in 1968. It seems reasonable to conclude, therefore, that the results of the 1968 study are germane in 1981.

Table 15. *Earnings (gross margins) of dairying and cattle*

	Dairying		*Cattle*	
	£ (1980)/ Livestock unit	*% Share of gross output*	*£ (1980)/LU*	*% Share of gross output*
1968	347	79	145	72
1973	400	81	146	na
1978	378	70	154	61
1980	237	63	100	54

Source: As for Appendix Table 9.

However, the 1968 Team did apply very strict performance standards. If the assumptions about growth and discount rate used in the analysis of arterial drainage are applied to 1980 profit levels, the DCF-cost ratio in Table 14 would increase from 2.32 to 3.80. This compares very favourably with the ratio 1.076 for arterial drainage projects under similar assumptions in Table 9.[21] It suggests that overall, field drainage is still well worthwhile from the national viewpoint. However, what we cannot know without an up to date survey is whether the field drainage programme has run into diminishing returns since 1968. It would be natural to expect that the highest yielding investments were undertaken first. The programme may now have worked its way down to less attractive opportunities.

The effective rate of state support in 1968 was 58 per cent of the cost of drainage. In 1981 the rate of grant varied between farmers as seen in Table 13. It averages out at 56 per cent, roughly the same as in 1968.

21. This revision would alter the regional benefit-cost ratios for field drainage as follows: west (1.89), mid-south (1.48), south-east (3.49), north-east and midlands (5.05).

V SUGGESTIONS

The evidence available implies that the best investment opportunities in arterial drainage have already been undertaken. Although we have no time-series data, we expect that the same is true in the case of field drainage. With regard to the latter, it is clear that there is very great variation among projects in terms of costs and payoff, with some investments yielding very attractive rates of return and others not even covering costs. It follows that considerable care should be taken so as to ensure that our outlays on arterial and field drainage - now amounting to about £30 million annually - should be invested to maximum national advantage. The state should bring to this task the same level of analysis and planning which a successful private corporation would if it were investing this sum per annum. Private sector norms would provide a useful starting point in deciding what is appropriate in this regard.

Re-distribution

In our recommendations we emphasise the economic efficiency dimension. However, sight should not be lost of the fact that drainage investment is also a re-distribution of funds, and that it may favour in this respect the relatively rich or the relatively poor. Since it comprises a substantial transfer of income-earning assets from taxpayers in general to specific individuals, it is clearly a convenient policy instrument for increasing the incomes of the less well-off. However, if such is to be a justification - it is not so used by the Office of Public Works - then the distribution effects should be clearly identified and other alternative means of re-distribution should be explored.

The EEC

Although the proportion of drainage investment contributed by the EEC has been very modest in the past, it is increasing

with the implementation of the Western Drainage Scheme. In our analysis we did not separate out the present or prospective EEC contribution; we examined the return to the total investment. Clearly, if we based our present net worth estimates on the Irish contribution alone, this would make the returns much more favourable. We eschewed this approach for a number of reasons: it is likely that there is a hidden quid pro quo involved in getting EEC funds; they are not costless. This effect may be quite subtle, e.g., our bargaining power at the agricultural price review stage is weakened if member states can point to favours which we have received elsewhere in the system, or it may take the more direct form of reduced appropriations from the Regional and Social Funds. Furthermore, we assume that the EEC is interested in allocating its resources effectively; the community will want to be assured that what is spent on drainage is allocated so as to achieve the greatest net effect, and to be informed if there are alternative options on which some of the resources could more beneficially be spent. We recognise that Ireland receives funds for drainage in part on the basis that the country is a "special case" in this respect. However, we believe that the spirit of that conviction could be retained by requiring that the resources be spent to increase the income generating capacity of those owners with land drainage problems; if this were acceptable, it would mean that funds would not have to be earmarked exclusively for a single purpose.

We turn now to a listing of suggestions respectively concerning arterial and field drainage.

Arterial Drainage

Overall, we are impressed with the methodology employed and the rigour with which it has been pursued, as described in Steering Group (1978) and Howard (1980). Focusing on the addition to landowner income is the correct measure of gross primary benefit, sensitivity analysis is skilfully employed, while not counting the multiplier effects of investment as a benefit is also correct, for reasons outlined in a previous section. Establishing an interdepartmental group to provide the analytical framework will have helped avoid many potential errors, if the US experience in this respect is any guide. There,

since 1938 the federal water development agencies have had a statutory requirement that the benefits of proposed developments must exceed costs before development can proceed. However, no analytical guidelines were provided at the outset to the agencies involved. As a consequence, a heterogeneous set of practices and traditions became established which resulted in invalid analyses, and it has taken decades to correct the initial errors and arrive at appropriate analytical methods. However, there are aspects of the OPW analysis where we feel that improvement is possible.

(i) *Marginal Approach*

In scaling their prospective investment, the OPW does use a marginal approach to decide what to include and what to exclude in the project. For each channel, estimated expenditure is compared with the anticipated benefit, measured by the increase in the market value of the land. In the case of the Maigue scheme, only those channels were included where the ratio of costs to anticipated returns does not exceed 3.5:1. Even allowing for the limitations of increased market value of land as a measure of benefit - these are discussed later - this strikes one as a rather indulgent cut-off criterion. In addition, since in the global analysis the OPW uses estimated farm income increase as the measure of benefit rather than the land value increase, there is an inconsistency between the criterion used to scale the project and that which is used to assay its viability overall.

The OPW also uses an implicitly marginal approach to its assessment of some environmental impacts. Howard (1980) describes how, in the case of the Corrib/Mask catchment, the areas where drainage could be forgone at little loss in terms of net income forgone and which were also of considerable value for wildlife were identified, as were those areas where "drainage is essential if a scheme for the major portion of the catchment is to be formulated". By comparing crude rankings of areas for wildlife with those for economic draining potential, it is possible to avoid major errors, such as including in a scheme those areas which are very valuable for wildlife but which add little to net income if drained.

We feel that the marginal approach should be strengthened

and reformulated. Thus we are recommending a modification of the "entire catchment" approach of the 1945 Act; even small-scale improvements should be admissible, as was possible under the 1928 Act. The costs and benefits of the minimum size scheme for a catchment should first be estimated. This would be prepared for what a priori appeared to be the most attractive drainage opportunity. It would not necessarily involve working on the main channel, if the latter had "excess" capacity. If this investment yielded a positive present net worth, a further increment would be added, and if this *increment* in turn yielded a positive net worth, the next most promising addition would be analysed etc. The analysis would proceed until the last addition tested yielded a negative present net worth; this would define the optimum scale of the scheme. The important thing is to iteratively test various combinations at the margin in arriving at the appropriate scale. This will maximise the opportunity for trade-off analysis, where what would be forgone in financial returns at the margin in order to accommodate environmental, water supply and any other considerations which are germane, can be explored, at least in narrative form.

The opportunity to do this explicitly was forgone in the benefit-cost analysis of the River Maigue scheme. Two mutually exclusive alternatives - the preferred and the abridged schemes - were analysed (all estimates in 000s of 1975 £):

	Benefits	*Costs*	*Present net worth*	*Benefits/ costs*
Preferred	15402	8707	6695	1.77
Abridged	14486	8072	6414	1.80
Preferred abridged	916	635	281	1.44

The abridged version had a slightly higher benefit/cost ratio. However, as was shown earlier, this is not the appropriate criterion for choosing among mutually exclusive projects. It can be seen above that spending an additional £635,000 provides further benefits of £916,000 to yield an incremental present net worth of £281,000; the marginal benefit/cost ratio is 1.4. The marginal net financial gain - £281,000 - could be compared with any benefit which forgoing this return would yield in terms

of environmental or other benefits.[22] In doing so, it can be helpful to express the present worth amount in annual equivalent terms. In the case under review, over 50 years at 3.5 per cent, this works out at £12,252; this facilitates comparison with any annual hunting, fishing or other recreation experiences which must be forgone in order to garner the additional financial benefits.

(ii) *Shadow Pricing of Labour*

The major proportion of secondary benefits identified by the OPW comprise the shadow pricing of unemployed labour at zero. A difficulty arises with the use of this estimating procedure: as noted earlier, to legitimise the adoption of this convention would require that the interest rate applied be the return yielded at the margin in the best competing alternative investments - both public and private - *estimated using shadow prices*. This will be higher than the financially (rather than shadow priced) based rate of interest now used by the OPW. To arrive at this appropriate discount rate would require that all competing investments be shadow-priced, which is a task beyond the capacity of existing data and analytical resources. We recommend, therefore, that the estimation of secondary benefits *per se* be dropped. If it is felt that drainage investment employs more heretofore unemployed or underemployed resources than the alternative investments, the difference between the drainage investment-related impact in this respect and the alternative can be shown in the form of a separate display, as in attributable benefit.

(iii) *Non-Drainage Alternatives*

An important aspect to be addressed in benefit-cost analyses is whether there are more cost-effective means of achieving the net farm income-increasing objective for which the proposed project is being undertaken. In the study of the River Maigue drainage project, a scheme was discussed to achieve more efficient use of the target group's lands which had no drainage problems. However:

22. If the present net worth criterion had been applied, the preferred alternative would have had the greater net present value.

> . . . the valuation of such a scheme had to be abandoned because of the difficulty in identifying and measuring the relevant inputs and outputs. It was recommended that further consideration be given to determining the relationship between training and advisory costs and increased farmer capability. (Steering Group, 1978, p. 11)

This inability to examine non-drainage alternatives seriously weakens the conviction which can be associated with the conclusions of any study. In part this difficulty grows out of the restricted mandate under which the OPW must operate. It is charged with draining land rather than arriving at the most cost-effective means of increasing landowner income.

The recommendation in this context that further consideration be given to the relationship between training and advisory costs and increased farmer capability seems to imply that these (advising and training of farmers) are the key constraints to increased output. This in turn implies that any funds re-allocated from drainage would most effectively be spent on the achievement of these ends.

We feel that the matter of alternatives needs to be raised in a much broader context.

All major income-increasing alternatives should be subject to periodic appraisal, along the lines employed by the Survey Team (1968). Although it may appear to be a counsel of perfection to suggest that a wide array of alternatives be canvassed, the results of the analysis undertaken by the Survey Team illustrates the value of the insights which can be yielded by casting the net wide in reviewing policy choices.

(iv) *Ex-Post Analysis*

A key consideration in the analysis of drainage is the extent to which the investment opportunities created in this respect are actually acted upon by landowners. With regard to earlier schemes, we were assured by some observers that many landowners did not make the necessary follow-up investments, but these comments were not based on any independent analysis of the data. In this situation the OPW had no choice but to do what they have done, namely, to draw on the opinion of experienced personnel in the local Land Office in this regard,

and test the sensitivity of the results for changes in the assumed rate of participation. As is to be expected, the net returns are highly sensitive to changes in participation rates. In the case of the Maigue scheme, the benefit-cost ratio falls from 1.77 to 1.16 when the assumed degree of response falls from 90 per cent, which was the central assumption of the study in this respect, to 50 per cent.

We recommend that *ex post* analysis be used to verify (or otherwise) assumed rates of participation. Such review should not be confined to those four schemes which have been formally analysed. It should be possible to derive a rough estimate of the actual "with-without" effects of drainage on the schemes which have been completed since 1948. The use of *ex post* analysis should also be extended to include a review of price, productivity growth and input-output assumptions.

(v) *Project Ranking*

In analysing any specific project, many expectations concerning matters such as price, output, landowner participation, the interest rate etc., may well turn out to be incorrect. However, most of such inaccuracies will be shared by all projects. It follows that benefit-cost analysis is more powerful as a means of ranking projects than as an absolute indicator of merit. This advantage has not yet been availed of in regard to arterial drainage projects. The information available supports the economic logic of draining catchments in the rank order suggested in 1945 by the Chief Engineer of the OPW, and which has since been followed.

The evidence available supports (put more formally, it does not allow us to reject) the hypothesis that the most economically attractive drainage opportunities have been undertaken. This is clearly consistent with the underlying rationale of the OPW priorities. However, we would expect that the a priori ranking of the most promising opportunities would be easier than assigning priorities to those remaining. In addition, since we anticipate that those remaining are relatively higher cost and with a lower payoff, the opportunity costs of a major error in the order in which the remaining projects are undertaken could prove to be very high. We feel that it would be useful to verify (or otherwise) that the existing OPW ranking should continue to be adhered to

for those schemes yet to be undertaken.

(vi) *Improvement in Land Value*

The improved market value of land has certain deficiencies as a measure of the value of farming benefits from drainage. However, it has the advantage that it is based on a "real" comparison by the assessor of drained and undrained land. The income flow measure, on the other hand, is based upon hypothetical behaviour which so far has not been validated by actual experience, and upon a questionable nil value on the farmer's own extra labour on the reclaimed land. We, therefore, feel that the land value measure may not be far wide of the mark as a useful measure of benefit. Perhaps current research at An Foras Talúntais on the determinants of land price will clarify the latter's role as a proxy for income generating capacity.

(vii) *Pricing*

Based on the fragmentary evidence available concerning pre-1945 drainage schemes, for the benefit of which in each case some charge was assessed to landowners, it appears as though price plays a role in eliminating the least worthy projects. It also tends to reduce the area drained by both increasing administrative costs and delays, and reducing the degree of participation in a particular area. Nevertheless, under the 1842, 1863 and 1925 Acts, 250,000, 130,000 and 70,000 acres respectively were drained, while landowners respectively bore 48.1, 93.6 and 23.1 per cent of the costs. The assessment of charges to a relatively large number of owners complicates matters, and is likely to slow down the rate at which areas are drained. However, even a modest charge would eliminate much of the pressure for what is now a free good, while helping to allocate funds to the most promising opportunities. The cost-sharing approach now employed in group piped water supply schemes might provide a useful model in this respect.

(viii) *Institutional Considerations*

We have seen that the legislative mandate of the OPW does not embrace responsibility for non-drainage aspects of river basin management; water supply, environmental considerations and other landowner income generating opportunities fall

outside of the agency's terms of reference, if the latter are strictly defined. This narrowness of focus can result in significant sub-optimisation. The OPW has had some success in overcoming these limitations, by the use of inter-organisational committees and interaction with experts. However, this approach is limited in a number of related ways:

(a) It depends for its effectiveness on the extent and quality of the co-operation which the OPW receives from the relevant agencies. In some cases, e.g., water supply, the units in question - local authorities - may not be sufficiently staffed and organised to anticipate needs and to identify opportunities.
(b) The drainage section of the OPW is evaluated chiefly by the acreage of area drained. These additional responsibilities must be undertaken in an institutional environment wherein the agency gets little credit for non-drainage related activities.
(c) In both the design and execution of schemes, day-to-day decisions are taken which cannot readily be dealt with by a committee. Furthermore, when individuals of different disciplines - e.g., hydrologists, economists, engineers, wildlife managers, fisheries scientists etc., - work together as a team in the same organisation and with the same overall mission, they can teach each other and develop a professional and personal rapport which is difficult to achieve with a more fragmented organisational structure.
(d) A single purpose agency has a major difficulty if, and when, it is decided that the task for which it has been mobilised is no longer necessary. This stage has by no means yet been reached in the case of arterial drainage in Ireland. However, if the OPW had a multi-purpose mission, it could gradually shift emphasis as the circumstances required, and still maintain its organisational cohesion and *esprit de corps*.

Given the interdependence involved in river basins, and the multi-faceted nature of the skills required for their management, most Western countries have adopted river basins (catchments) as the jurisdictional units, and they apply integrated multi-purpose skills in their management. This approach has not been adopted in Ireland: it would further

dilute the already meagre powers of the local authorities, and the several agencies already involved in water might lose some influence. However, since the main preoccupation of local authorities in this area is the provision of water to households, rather than river basin management, they may not object to ceding some authority in this latter respect. We feel that the river basin approach deserves serious consideration, and that the OPW, because of its experience in operating at this scale, should be centrally involved. Failing a fundamental re-appraisal of river basin management in Ireland, we recommend that the OPW integrate the requisite skills in economics, wildlife management, agronomy, ecology etc., into its organisation. This would give it the day-to-day skills needed, and allow it to enter into professional dialogue with the Forest and Wildlife Service, the Central Fisheries Board, the Department of Fisheries, An Foras Forbartha, the local authorities, interest groups, the public, etc. The OPW should be given some legislative mandate in the relevant areas as they are affected by drainage.

The costs of such an expansion in personnel would amount to about £200,000 (£ 1981) annually, comprising 1.5 per cent of estimated outlays on arterial drainage in 1981. It is impossible to quantify the improvement which such an outlay would engender. Further to the case made above, all we can say is that it would be consistent with the staffing approach used in many other countries.

(ix) *Cost Allocation*

Should the costs of accommodating environmental, water supply and other concerns be allocated to drainage, or borne by the affected parties? This is a property rights question. If it is assumed that the rights to the fisheries, wildlife etc., are owned by the public, then whichever interest wishes to diminish these must, in theory, either compensate the losers or make good the damage caused. If, on the other hand, the rights are vested in the landowners, then those with interests in fisheries, wildlife etc., must compensate the landowners if they want the latter to accommodate their interests. We feel that the costs of accommodating the non-drainage interests appropriately should be an integral component of the drainage programme.

This approach would be consistent with that applied to industrial and residential developments; through the planning permission process, developers typically have to incur the bulk of the costs of accommodating the concerns of adjacent landowners and the general public. However, some rights which rest with objectors under existing planning law - notably, the right to appeal to An Bord Pleanala - would not be appropriate in the case of land drainage.

There have been misgivings expressed by a few non-Irish members of the European Parliament concerning the potential environmental damage caused by the drainage programme. The European taxpayers are helping to finance this programme, and the level of environmental awareness and concern in the other EEC member countries tends to be higher than it is in Ireland. It is likely then that there will be continuing interest on the part of European representatives in the environmental dimension. We feel that it would be preferable to anticipate this concern by taking the actions proposed, and publicising them, rather than be required to do so at a later stage.

(x) *Research and Training*

The Office of Public Works does not conduct research into alternative methods of drainage, but does keep up to date with developing technologies. There are areas where a modest investment in drainage research might yield substantial dividends. Drainage maintenance costs per unit length have shown a real long-term annual average rate of growth of two per cent. As the total length of channels to be maintained increases, this combines with the growth rate to yield a rapidly expanding maintenance budget. Research - biological, and economic as well as engineering - could be applied to try to reduce existing costs, and develop drainage methods which would be cheaper to maintain. Research could also be applied to the development of drainage construction and maintenance approaches which are in harmony with environmental and other values, or which can accommodate them at reduced cost. These are simply suggestive of what might be undertaken. We have no special insight or expertise in this area, but we feel that this possibility should be seriously investigated.

(xi) *Drainage Maintenance*

The scanty evidence available indicates that maintenance of channels by local authorities is in some cases both more expensive and more environmentally deleterious than it would be if it were undertaken by the Office of Public Works. We recommend that this matter be investigated further. If it proves that such is the case, either the maintenance should be centralised, as envisioned in the 1945 Arterial Drainage Act, or the performance of the local authorities in this respect should be up-graded.

Field Drainage

(i) *Economic Appraisal*

Many of the points made in this regard concerning arterial drainage apply with equal force to field drainage. A listing of investment opportunities should be compiled and ranked. Each drainage investment should be scaled using marginal analysis. The most promising income increasing alternatives should be assayed. However, most of the field drainage investments are small; a full appraisal can only be justified for the largest such schemes. For the rest (comprising the bulk of field drainage activity), some rule of thumb procedures should be devised which would allow the most and the least promising opportunities to be quickly identified.

(ii) *Incentives for Landowners*

When the Survey Team analysed the issue in 1968, they expressed concern that some landowners were getting the drainage work done but then were not utilising the land to full economic advantage. To help ensure that this problem would be minimised, they suggested the following:

(1) Grants should not be given to applicants who are neglecting the sound land on their holdings or who have failed to make proper use of land drained under previous schemes.
(2) Proper maintenance of previous drainage should be a prerequisite for further grant-aid.
(3) The Advisory Service should be involved with farmers in planning the schemes themselves and in utilising and maintaining them when complete.

Under the Land Project, all land-holders were eligible. It was administered by technical staff who had no brief to advise farmers on the proper place of drainage in their business. The major protection against waste was the grant ceiling. It weeded out costly jobs because the contribution by the farmer escalated rapidly on these.

The Farm Modernisation Scheme confined grants to landholders with farming as their main occupation. It contained somewhat stricter screening of applicants along the lines recommended in (3) above. It did not attempt to introduce the tough line on eligibility recommended in (2). All proposals had to be passed by the Advisory Service. However, this was more an administrative procedure than an economic assessment. For development farmers they also had to be set in the context of a farm plan agreed with the Adviser, and strict accounts had to be kept. In practice the advantages of development status were not attractive, so most farmers opted for the lower status where they were allowed much more laxity in specifications of investment proposals.[23]

Between 1974 and 1979, 92,000 applicant farmers, or about two-thirds of the farmers in the country, had to be assigned to the appropriate development status. Six-year plans had to be drawn up for 17,000 of them. The paperwork involved proved burdensome on the Advisory Service and there were many complaints that the normal duties of advising on appropriate investment and husbandry suffered. This cast some doubt on whether the reforms helped get better value for state money.

The administration of the Western Drainage Scheme has largely reverted to the Land Project style. All landholders are eligible and the scheme is administered by technical officers. Some of the Survey Team's criticisms in 1968 are applicable.[24]

We recommend that the Survey Team's proposals be adopted. For the largest schemes, we suggest also that part of the

23. Under this lower status, farmers needed a certificate from their Adviser testifying that: the works are necessary to the upkeep of the land; are undertaken in proper order of priority; and will be fully utilised. In addition to the above, the development farmer has to state all intended investments during a six-year plan, show how they will improve the farm enterprise from its initial state to a targetted level of income. As well as keeping strict farm accounts, the development farmer also has to reveal any non-farm income.

24. The department do issue some guidelines to grant administrators with a view to getting run down past work restored. These guidelines are not public and they do not seem to prevent applications from going ahead.

grant be withheld and paid over time, with payment being made contingent on compliance with economically efficient use of the land. The IDA pays its grants over time so as to encourage compliance by the grantees with agreed employment and environmental standards. It would help reassure taxpayers that their contributions were not being wasted if a similar approach were adopted in the case of grants for drainage.

(iii) *Ex Post Analysis*

The Survey Team in 1968 recommended that "a small unit within the administrative staff should organise regular data collection and appraisal of the programme". This suggestion has not been acted upon.

A representative sample of field drainage projects should be selected at the time the work is done and the costs and expected returns recorded. At least once thereafter these should be re-examined to compare actual performance with that expected at project initiation. In order to avoid the "Hawthorne effect" - where those being examined modify their behaviour so as to conform with what is "expected" of them - the landowners should if possible not be aware that they have been selected for this purpose.

(iv) *Rate of Subsidy*

The subsidisation of drainage is proportionately higher than that which is provided to other farm inputs such as fertilisation, improving livestock quality, increasing stocking, building more and better farm buildings etc. Net revenue maximising landowners will choose the mix of inputs which will equate returns at the margin. Thus they will keep "adding" drainage up to the point when the return to the last increment *of their own expenditure* for this purpose just equals the return yielded by the equivalent outlay elsewhere. This explains why the Land Project survey team discovered that many farms were forgoing alternative investment opportunities in favour of drainage when the former would yield a greater net difference between total revenues and total costs. They opted for more drainage because, with the preferential rate of subsidy, it was more profitable for them to do so. Net income to farmers could be increased if resources were to be re-allocated from drainage to other

activities. We noted earlier that landowners (especially those of advanced years) may underinvest in drainage relative to other inputs, because the bulk of the benefits accruing from the former are so long deferred. On this basis, therefore, one can make a case for the state contributing a higher proportion of the cost of drainage. However, the findings of the land project survey team imply that this "favouritism" has gone too far, and that overall net returns to agriculture are suffering as a result.

We, therefore, recommend that, if maximisation of net farm income is a goal, serious consideration be given to moving in the direction of achieving neutrality *vis-à-vis* subsidies, i.e., narrowing the differential in the share of costs borne by the state *vis-à-vis* drainage and other farm inputs. Since arterial drainage is provided free, this would involve considering an assessment to recoup from the beneficiaries a portion of the costs incurred. We recognise that this would pose some administrative and political difficulties. However, the latter would be eased perhaps by the fact that the subsidy level on other inputs would be increased.

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Appendix Table 1: *Spending on the arterial drainage programme*

	Expenditure (£000)							
	At current prices			*At constant 1980 prices*				*Survey and construction as a % of public capital programme*
	Survey	*Construction*	*Maintenance*	*Survey*	*Construction*	*Maintenance*	*Total*	
1950/51	6.3	356.5	—	71.6	4051.1	—	4122.2	1.0
1951/52	11.0	464.2	—	112.2	4736.7	—	4848.9	1.1
	16.3	526.1	—	150.9	4871.3	—	5022.2	1.2
	14.9	542.4	—	138.0	5022.2	—	5160.2	1.3
	16.6	698.2	—	156.6	6586.8	—	6743.4	1.6
1955	15.9	729.5	2.6	147.2	6754.6	24.1	6925.9	1.6
	18.2	698.8	22.1	156.9	6024.1	190.5	6371.5	1.6
	22.4	657.0	22.9	185.1	5429.8	189.3	5804.2	1.7
	27.6	641.2	33.2	224.4	5213.0	269.9	5707.3	1.8
	28.3	839.2	38.0	233.9	6935.5	314.0	7483.4	2.0
1960	28.6	958.5	58.1	228.8	7668.0	464.8	8361.6	1.9
	25.2	1193.8	69.7	193.8	9183.1	536.2	9913.1	2.1
	22.8	1561.3	84.9	166.4	11396.4	619.7	12182.5	2.4
	26.2	1849.3	93.1	189.9	13400.7	674.6	14265.2	2.4
	24.9	2125.2	127.7	167.1	14263.1	857.0	15287.2	2.2
1965	27.2	1808.1	161.7	177.8	11817.6	1056.9	13052.3	1.8
	23.7	1465.9	168.5	148.1	9161.9	1053.1	10363.1	1.5
	24.9	1467.3	180.2	150.0	8839.2	1085.5	10074.7	1.3
	44.8	1470.0	239.2	259.0	8497.1	1382.7	10138.8	1.1
	39.3	1515.4	2363.3	204.7	7892.7	1371.4	9468.8	0.9

Appendix Table 1: *Spending on the arterial drainage programme (continued)*

	Expenditure (£000)							*Survey and construction as a % of public capital programme*
	At current prices			*At constant 1980 prices*				
	Survey	*Construction*	*Maintenance*	*Survey*	*Construction*	*Maintenance*	*Total*	
1970	45.1	1636.8	385.1	211.7	7684.5	1808.0	9704.2	0.9
	38.7	1320.3	518.7	164.0	5594.5	2197.9	7956.4	0.6
	30.0	1215.4	621.1	114.9	4656.7	2379.7	7151.3	0.5
	42.7	1381.6	778.9	144.7	4683.4	2640.3	7468.4	0.4
	52.0	1410.8	731.1	133.3	3617.4	1874.6	5625.3	0.5
1975	58.7	2689.8	1120.5	125.7	5759.7	2399.4	8284.8	0.6
	76.1	3281.7	1331.5	138.4	5966.7	2420.9	8526.0	0.6
	90.3	3789.7	1380.5	138.1	5794.6	2110.9	8043.6	0.6
	90.1	4369.3	1785.5	125.1	6068.5	2479.9	8673.5	0.6
	165	6810	2135.7	198.1	8175.3	2563.9	10937.3	0.7
1980 (P)	220	9062	2944	220	9062	2944	12226	0.8
1981 (E)	230	9587	3671	190	7923	3034	11147	0.6
Total				5466.4	232731.2	38944.2	277040.8	

Note: The data include direct spending under the respective subhead plus an apportionment to each of engineers' salaries and travelling expenses, and of services of engineering plant, machinery and stores. Head office costs of the Office of Public Works are not included. The data include the 50 per cent EEC contribution to Arterial Drainage in the west started in 1979. The deflator used is the implicit price index of "Other Building and Construction (including Land Rehabilitation)" derived from the National Income and Expenditure Accounts. (P) = Provisional (E) = Estimate.
Source: Appropriation Accounts: Budget Booklet.

Appendix Table 2: *Progress under field programmes*

	State grants paid current prices	*£000 Constant 1980 prices*	*Area of land improved (acres)*	*State grants paid per acre (£ 1980)*	*Grants paid as % of public capital programme*
1951	272.1	2776.5	57,762	48.1	0.6
	401.6	3718.5	75,651	49.2	0.9
	490.4	4540.7	77,985	58.2	1.1
	700.3	6606.6	84,158	78.5	1.5
1955	980.5	9078.7	93,868	96.7	2.2
	1298.2	11191.4	109,958	101.8	2.8
	1260.9	10420.7	89,635	116.3	3.1
	1285.9	10454.5	93,749	111.5	3.4
	1669.7	13799.2	114,636	120.4	3.8
1960	1699.0	13592.0	127,626	106.5	3.3
	1365.9	10506.9	91,560	114.8	2.3
	1583.5	11558.4	98,618	117.2	2.4
	1499.8	10868.1	88,045	123.4	1.9
	1721.2	11551.7	93,565	123.5	1.8
1965	1683.7	11004.6	89,388	123.1	1.7
	1685.2	10532.5	71,311	147.7	1.7
	2365.3	14248.8	89,763	158.7	2.1
	2484.7	14362.4	93,940	152.9	1.8
	2534.7	13201.6	91,790	143.8	1.5
1970	2997.3	14071.8	104,933	134.1	1.6
	2737.8	11600.8	93,728	123.8	1.3
	2615.5	10021.1	85,832	116.8	1.1
	2714.3	9201.0	86,297	106.6	0.8
	2576.0	6605.1	80,938	81.6	0.9
1975	3527.7	7554.0	103,942	72.7	0.7
	5774.4	10499.0	152,734	68.7	1.1
	5304.1	8110.2	96,331	84.2	0.8
	7626.2	10591.9	116,564	90.9	1.0
	9503.4	11408.6	119,873	95.2	0.9
1980	16556.0	16556.0	152,561	108.5	1.3
Total		310233.3			

Notes:

(i) Expenditure includes grants paid only. The cost of administering the scheme is not shown.

(ii) The data incorporate the Land Project, the Farm Modernisation Scheme from 1975, the Western Drainage Scheme from 1979.

(iii) Up until 1958, farmers could opt for field improvement by state contractors. Under this part of the Land Project, 149,354 acres were improved at a total cost to the state of about £43 million at 1980 prices. This option was most popular in the first half of the 'fifties. The approximate phasing of the work is added in Graph 2.

(iv) The deflator used is the implicit price index of "Other Building and Construction (including Land Rehabilitation)" derived from the National Income and Expenditure Accounts.

Source: Department of Agriculture.

Appendix Table 3: *Progress of drainage programmes by county*

	Arterial drainage 1945–80		*Field drainage 1949–78*	
	(Acres 000)	*% of farm land*	*(Acres 000)*	*% of farm land*
Carlow	—	—	68.5	36.7
Dublin	3.1	1.9	31.1	18.8
Kildare	14.7	4.1	128.4	35.6
Kilkenny	—	—	108.0	23.7
Laois	4.0	1.2	123.4	36.5
Longford•	11.4	5.4	36.9	17.4
Louth	11.7	6.7	32.6	18.6
Meath	68.6	12.4	146.6	26.6
Offaly	84.6	23.4	71.2	31.2
Westmeath	85.2	22.5	119.8	31.7
Wexford	4.9	1.0	173.7	34.2
Wicklow	—	—	87.2	29.7
LEINSTER	288.2	7.2	1127.4	28.5
Clare•	10.3	1.8	86.9	15.0
Cork	2.0	0.1	272.3	20.1
Kerry•	38.1	7.1	171.0	31.9
Limerick	54.2	9.1	140.5	23.6
Tipperary	8.1	0.9	237.1	27.4
Waterford	1.0	0.3	93.3	28.7
MUNSTER	113.7	2.7	1001.1	23.5
Galway•	116.5	14.0	179.0	21.5
Leitrim•	2.2	0.8	35.6	12.9
Mayo•	64.7	10.6	149.7	24.4
Roscommon•	2.2	0.4	74.7	15.2
Sligo•	10.8	3.6	40.1	13.3
CONNAUGHT	196.4	7.8	479.1	19.1
Cavan•	7.1	1.8	101.3	25.5
Donegal•	8.4	1.9	107.4	23.9
Monaghan•	4.4	1.6	71.2	25.2
ULSTER	19.9	1.8	279.9	24.7
STATE	618.2	5.2	2887.5	24.3

•These are counties "designated" for assistance under the Western Drainage Scheme. Part of West Cork and West Limerick are also "designated".

Notes:

(i) Field drainage includes Land Reclamation as well as field drainage proper.

(ii) Area improved under arterial programmes included both agricultural land and bog land.

(iii) Farm land includes areas under crop and pasture.

Sources: Doherty (1980) and Office of Public Works.

Appendix Table 4: *Construction cost of arterial works in river catchments drained*

Catchment	*Duration of works*	*Costs per acre of agricultural land benefiting (£ 1980)*		
		At design (£ 1980)	*Actual (£ 1980)*	*Overrun of design cost (%)*
Major				
Brosna	1948-55	247.2	248.4	-0.6
Glyde and Dee	1950-57	405.8	395.8	-2.5
Feale	1951-59	453.8[1]	441.1[1]	-2.8
Corrib-Clare	1954-64	370.5	478.4	+29.1
Maine	1959-63	523.5	545.1	+4.1
Inny	1960-68	367.4	445.6	+21.3
Moy	1960-71	522.6	795.7	+52.3
Deel	1962-68	565.9	499.6	-11.7
Corrib-Headford	1967-73	436.4	501.9	+15.0
Boyne	1969-	472.3		
Maigue	1973-	437.8		
Corrib-Mask	1979-	435.8		
Boyle	Proposed	531.6		
Minor				
Nenagh	1955-60	392.7	423.0	+7.7
Ballytoige-Kilmore	1959-61	334.8[1]	297.0[1]	-11.3
Broadmeadow and Ward	1961-64	427.7	255.2	-40.3
Killimore and Cappagh	1962-68	385.2	515.9	+33.9
Bonet	Proposed	623.3		

[1]Costs per acre of *all* land benefiting (i.e., includes any bogland benefiting).

Note:

Major catchments are those in excess of 100,000 acres. Minor catchments are those of 25,000-100,000 acres. The OPW also carry out schemes on smaller catchments and on estuarine embankments. Only 10 per cent of land drained by completed schemes has fallen into the latter two categories.

Expenditure is deflated by the implicit price index of "Other Building and Construction (including Land Rehabilitation)" derived from the National Income and Expenditure Accounts.

Source: Estimates for Public Services.

Appendix Table 5: *Improved market value of agricultural land drained in river catchment schemes*

Catchment	*Year work commenced*	*Improved market value of land at constant £ 1980*[3] *As % of pre-drainage value*	*Per acre of farm land benefiting*	*As % of construction costs*
Major				
Brosna	1948	81.1	449	180.5
Glyde and Dee	1950	78.3	836	211.2
Corrib-Clare	1954	84.7	844	176.3
Maine	1959	52.0	616	113.0
Inny	1960	51.6	319	071.5
Moy	1960	62.3	488	061.4
Deel	1962	NA.	276	055.3
Corrib-Headford	1967	54.0	307	061.2
Boyne[1]	1969	47.2	401	085.1[1]
Maigue[1]	1973	32.4	360	082.3[1]
Corrib-Mask[1]	1979	50.1	166	038.2[1]
Boyle[2]	Proposed	51.1	223	041.9[2]
Minor				
Nenagh	1955	76.6	1562	369.4
Broadmeadow and Ward	1961	29.4	474	185.9
Killimore and Cappagh	1962	NA.	381	073.9
Bonet[2]	Proposed	56.5	231	037.1[2]

[1]These schemes are in progress; improvement value is shown as a proportion of budgeted costs.

[2]These schemes are at proposed stage; improvement value is shown as a proportion of budgeted costs.

[3]Construction costs were brought to 1980 prices using the National Accounts deflator for "Other Building and Construction". The Land Price Index used is based on a survey of Auctioneers in the post - 1967 years. For previous years it is based on the price of land paid by the Land Commission.

Source: Office of Public Works; Estimates for Public Service. Land Prices courtesy of Paul Kelly (1979) (An Foras Talúntais).

Appendix Table 6: *Improved land values and present discounted value of primary benefits and cost compared*

	Maigue	*Corrib-Mask*	*Boyle*	*Bonet*
	£000 (1977 Prices and profitability)			
Farm revenue	28,078	27,342	31,697	6,036
Farm revenue (low growth)	19,811	20,051	19,652	3,662
Land value	7,310	3,053	2,380	537
Total investment costs	17,204	13,175	10,323	3,081
Total investment costs (low growth)	15,918	12,346	9,227	2,834
Net farm income	19,697	22,686	26,580	4,947
Net farm income (low growth)	12,716	16,142	15,631	2,820
Drainage costs	8,823	8,437	5,206	1,992
Ratio analysis	*at 1977 prices and profitability*			
Land value to net farm income	37.1	13.5	9.0	10.9
Land value to net farm income (low growth)	57.5	18.9	15.2	19.0
Farm revenue to total investment	1.632	2.075	3.071	1.959
Farm revenue to total investment (low growth)	1.245	1.624	2.130	1.292
Ratio analysis	*at 1980 prices and profitability*			
Land value to net farm income	59.8	19.6	14.0	17.6
Land value to net farm income (low growth)	97.4	27.9	24.2	32.3
Farm revenue to total investment	1.125	1.430	2.065	1.295
Farm revenue to total investment (low growth)	0.870	1.116	1.450	0.850
Ratio analysis	*at prices in original analysis*			
Land value to net farm income	24.3	15.3	12.0	17.5
Farm revenue to total investment	1.778	1.952	2.476	1.413

Note: Net farm income is present discounted value of future farm revenue less all on-farm costs. Farm revenue is present discounted value of farm revenue (gross of on-farm costs) *plus* saved maintenance. Cost (I) is cost of arterial drainage construction and additional maintenance. Cost (II) is cost of arterial drainage construction and gross maintenance plus all on-farm costs. Low growth assumed no growth in the real value of farm profit per livestock unit, and 1 per cent growth in real stocking rates up to the horizon.
Source: Office of Public Works and own reworkings.
Deflators as in Appendix Table 5.

Appendix Table 7: *Secondary effects of drainage and the adjusted benefit-cost ratios*

	Maigue	*Corrib-Mask*	*Boyle*	*Bonet*
		(£000 1977 prices)		
Wages to the unemployed	4988	4855	3756	1243
Drainage of bogs	—	39	171	1
Other	639	77	134	—
Total secondary benefits	5627	4971	4061	1244
Disruption to fishing	433	155	446	103
Benefit-cost ratios				
Primary:				
at 1977 prices	1.632	2.075	3.071	1.959
at 1977 prices (low growth)	1.245	1.624	2.130	1.292
at 1980 prices	1.125	1.430	2.065	1.295
at 1980 prices (low growth)	0.870	1.116	1.450	0.850
Primary and secondary:				
at 1977 prices	1.911	2.424	3.427	2.286
at 1977 prices (low growth)	1.556	2.002	2.451	1.670
at 1980 prices	1.396	1.774	2.338	1.626
at 1980 prices (low growth)	1.171	1.484	1.781	1.226

Appendix Table 8: *Price indices for land, consumer goods and construction (1950–80)*

	Land prices (1966 = 100)	*Consumer prices (Mid-August 1953 = 100)*	*Construction prices (1970 = 100)*
1950	29.8	80.8	41.2
	34.9	87.2	45.8
	26.3	94.8	50.6
	31.5	99.8	50.9
	34.1	100.1	49.8
1955	40.9	102.7	50.9
	43.0	107.1	54.4
	41.2	111.5	56.9
	39.6	116.5	57.9
	49.9	116.5	56.8
1960	53.4	117.0	58.5
	51.1	120.2	61.0
	84.9	125.3	64.1
	91.2	128.4	64.7
	100.9	137.0	69.7
1965	95.2	143.9	71.8
	94.5	148.2	75.1
	100	152.9	77.9
	146.1	160.1	81.1
	160.7	172.0	89.9
1970	187.6	186.1	100
	247.2	202.8	110.5
	312.4	220.2	122.4
	465.2	245.4	138.6
	549.4	287.0	183.1
1975	670.8	346.9	219.3
	942.7	409.3	257.9
	1307.9	465.2	306.8
	1470.8	500.6	337.8
	2657.3	566.8	390.7
1980	1656.2	670.0	469.2

Notes and Sources:

(i) The land price index is based on a survey of auctioneers since 1967; for earlier years it is linked with data on the price of land by the Land Commission. (Data by courtesy of Paul Kelly of An Foras Talúntais).

(ii) Consumer price index from *Irish Statistical Bulletin.*

(iii) Construction price index is the implicit price deflator used in the National Accounts for "Other Building and Construction".

Appendix Table 9: *Earnings of main farm enterprises (gross margins)*

	Dairying (Creamery)			*Cattle*			*Wheat (Spring)*			*Barley (Feeding)*		
	Current prices £/LU	*Constant prices £(1980)/LU*	*As % of gross output*	*Current prices £/LU*	*Constant prices £(1980)/LU*	*As % of gross output*	*Current prices £/acre*	*Constant prices £(1980)/acre*	*As % of gross output*	*Current prices £/acre*	*Constant prices £(1980)/LU*	*As % of gross output*
1966/7	50	312	79	17	106	72	32	200	73	20	125	68
1967/8	57	343	81	23	139	74	36	217	75	23	139	69
1968/9	60	347	79	25	145	72	46	266	78	25	145	70
1969	na	na	na	na	na	na	na	na	na	na	na	na
1970	na	na	na	na	na	na	na	na	na	na	na	na
1971	na	na	na	na	na	na	na	na	na	na	na	na
1972	109	418	82	37	142	na	34	130	67	26	100	63
1973	118	400	81	43	146	na	66	223	78	47	159	72
1974	97	249	71	36	92	na	61	156	71	56	144	69
1975	129	276	72	59	126	na	82	175	71	58	124	64
1976	178	324	75	66	120	55	86	156	69	63	115	64
1977	237	363	74	87	133	56	148	226	77	123	188	75
1978	272	378	70	111	154	61	127	176	72	107	149	69
1979	262	315	65	104	120	57	136	163	71	101	121	65
1980	237	237	63	100	100	54	97	97	61	87	87	59

Source: Farm and Food Research (1972-80); Farm Management Surveys (1966-69).

Note: Deflator used is the Construction Price Index. Gross Margin is the gross output of the enterprise less direct costs. It represents the return to overhead costs, family labour, capital investment and management. LU = Livestock Unit.