Trends in irrigation development

A. F. E. ZAGNI

Mr R. B. Bulman, Consulting Engineer

Since salinity problems arise mainly from overwatering they would be minimized if the 100% efficiency, suggested in § 27, were achieved. The need for leaching might then be eliminated.

32. Irrigation inefficiency in day to day running is often encouraged by over-design of capital works in the distribution system. As suggested in reference 12, in this context any factor of safety should be applied in the opposite sense from normal engineering practice. Also, if the design of capital works is based on a planned soil moisture deficit at the end of the driest period, there will not only be a saving in capital cost but waste of water will be inhibited.

33. It is true that under spray and surface irrigation methods 100% efficiency is not possible, although it is theoretically with sub-irrigation methods as there need be no application losses.

34. There is also the intriguing possibility of exceeding 100% irrigation efficiency in the classical sense. This would be achieved in a system of closed circuit irrigation[13] but capital costs might rule this out except in special economic circumstances. This is in contrast to the return flow methods referred to in § 22, which can only encourage inefficiency.

35. Experience of sub-irrigation has not been happy in the past and it is unfortunately largely ignored at the moment. Its possibilities should be carefully re-examined because of the pressing need for higher efficiencies. With the availability of new materials, previous difficulties may be easily overcome and its many advantages realized. With the elimination of application losses under sub-irrigation it will be possible to arrange for continuous application controlled automatically. This will allow a reduction in the capacity and hence capital cost of the distribution system. This would make it more economic to put the whole of the distribution system underground. This in turn will reduce distribution losses and also save land, and, further, would reduce the health hazards referred to in § 19.

36. To ensure maximum efficiency in practice, it would be necessary to provide automatic control responding to weather changes or directly to changes in soil moisture tension. In the latter case, the water in the final distribution stage would need to be under negative pressure. This might now be feasible as a result of research carried out by Hayward[14] for a totally different purpose.

37. The immense potential benefits derived from a successful system of sub-irrigation warrants considerable investment in research to this end. With so many of its members engaged in the development of irrigation throughout the world, it would be appropriate for the Institution of Civil Engineers to initiate a pertinent research programme.

Mr G. C. Awre, Sir William Halcrow and Partners

The Paper makes one hope that one day the thoughts will be expanded into a book, covering all aspects of irrigation development from the feasibility study to the operation and management of the project. This could provide background for and instil enthusiasm in young engineers, as well as giving fruitful reading to those already committed. It could also help to make irrigation engineers more aware of the requirements and their responsibilities outside the engineering aspects of an irrigation development.

Paper published: *Proc. Instn Civ. Engrs*, 1971, 50 (Sept.) 65–75.

39. The advantages of an irrigation engineer in acquainting himself with the interlocking factors at work in the conception, realization and successful operation of an irrigation development are illustrated by the failures which have resulted not from failure of any part of the scheme but from one stage or section, not apprehending or even appreciating the possible effect of its work on parallel or subsequent stages or sections, i.e. from a failure to continually bear in mind that each part of the development is a means to an end and not the end itself. Therefore, expertise from all stages and sections of an irrigation development should be represented in the planning from the beginning under an overall controlling authority—a conclusion which has already been reached in many irrigation developments.

40. Not that all the problems have been even theoretically solved. For instance, research is still required to fully understand the long-term effects of various methods of irrigation in different situations. Provision for research should be built into the plans for all irrigation schemes, except those where the effects can be reliably predicted from almost identical experience elsewhere. Such research provisions are especially required when it is planned to irrigate whole valleys, because good practice in one part of the valley can result in damaging another part unless the overall picture is carefully monitored. What is happening underground often requires the keenest investigation.

41. This overall and long-term approach is necessary to make the best of the 'consolidation era' which the Author mentions in § 30.

Mr S. R. Usher, Projects Department, Wright Rain Ltd

Although the Author has given a fairly detailed history of the development of irrigation throughout the world, I feel that the subject of overhead irrigation could have been dealt with more fully, as it is nowadays a most important sector of the irrigation industry.

43. As suitable land and water resources become more scarce, ways have to be found to increase the efficiency of use of the available land with regard to crop production. It has been acceptable for irrigation schemes to have efficiencies of water use of 20% or lower, as there has not been the pressure of a vastly growing hungry population behind the irrigators. However, with the size of the world population being as it is, and with the rate of increase showing no signs of declining, there can now be no wastage of any available resources.

44. Sprinkler irrigation can produce efficient water use under nearly all climatic conditions ranging between 70 and 90%. These figures can be substantiated by experiences in the field. For example there is a sugar estate in East Africa, where the summer temperature is in excess of 43°C in the shade and the humidity is low, and for the last five years the cane has been irrigated using an efficiency of 80% on the consumptive used figures. This estate has obtained crop returns for water applied in excess of nearly all others in the world. With these efficiency levels available, for a given quantity of water, up to three times the area that could be irrigated with flood irrigation can be irrigated with sprinkler irrigation, giving an increased yield/ha.

45. Sprinkler irrigation has often been criticized as being too expensive to install and use. Most sprinkler systems at present employ medium pressure sprinklers (about 3·5 kg/cm^2) and when this fairly low pressure is coupled with a reduction of 2/3 in the quantity of water required, then the running costs of the system are not outrageous when compared with flood irrigation. As far as capital cost is concerned, what should always be taken into account when the cost of a flood irrigation system is calculated is the preparation of the land. For efficient flood irrigation, the land has to be graded to accurate slopes. Even if there is only 30 cm of soil to be moved from one hectare, this requires a total excavation to the order of 3000 m^3, the cost of which is considerable when one considers that it not only has to be moved but graded and land planed as well. No levelling is required for sprinkler irrigation—indeed if it is done it can often destroy the structure and fertility of the soil, leading to

a decrease in crop yield which may take many years to make up. There are also other advantages in the use of sprinklers. The application rate of the sprinkler can be matched with the soil infiltration rate. This means that there is no capping or puddling of the soil, and no concentration of sorts on the soil surface. If leaching is required this can be done with sprinklers more efficiently than by flooding. In many dry areas of the world, subject to dust storms in summer, crop production can be lost by the residue of the storm laying on the plant. This can in fact destroy crops such as cotton but sprinkler irrigation with its overhead spray will wash the crop down as it irrigates.

46. Sprinkler irrigation can be used with unskilled labour as there is nothing, apart from the pump units (which would probably be required for flood irrigation anyway) that requires detailed training to handle. It is also entirely adaptable to automation, and can be used to protect high value crops against frost down to about $-6°C$.

47. Some sprinkler irrigation schemes have been installed not only to provide irrigation water, matched automatically with the soil moisture deficit in the crop area, but also to control the humidity and temperature levels of the area in which the crop grows, and protect against frost in spring. At the other end of the scale, sprinkler systems can be installed using lightweight portable aluminium laterals that require moving up to three or four times a day, thus tapping a pool of surplus labour and bringing real benefits to a community. In between these two extremes, sprinkler irrigation can be done by using any of several types of equipment which require varied degrees of capital and labour investment.

48. Sprinkler irrigation may not be the absolute answer to the problem of efficient use of land resources. However, with the world's population already at a level which some consider too high, and expected to double within the next 30 years, all available land and water resources must be used to their utmost. At the present state of irrigation technology, the adoption of advanced sprinkler irrigation systems can help to achieve this end.

Mr A. R. B. Edgecombe, Indian Service of Engineers (retired)

It is misleading to evaluate the size of an irrigation project by the length of the canal, § 9, which refers to the Ganges Canal; the length in operation is 4109 miles[15] (6610 km), comprising the main canal and branches (569 miles—915 km) and distributaries (3540 miles—5695 km). In addition there are 2427 miles (3904 km) of drainage channels.

50. The Ganges Canal commands a gross area of 5 066 522 acres (2 051 000 ha and a culturable area of 3 934 186 acres (1 592 000 ha), of which 1 705 924 acres (690 400 ha) is irrigable by the complete project.

51. The Author uses the expression 'colonial India' in § 9. India was never a colony.

Mr Zagni

Referring to **Mr Bulman** in § 31, I dispute that salinity problems mainly arise from over-watering. If drainage is unimpeded this is clearly not possible as water in excess of plant transpiration and soil evaporation can only flush residual salts. It is difficult to visualize how the need for leaching could be eliminated. All irrigation water (except perhaps in the rare case of complete desalination by distillation) contains a certain amount of salt. Over a prolonged period of irrigation in an arid environment, this salt is deposited in the root zone and at the soil surface by evapotranspiration, often with adverse effects on plant moisture uptake or by toxicity unless leached.

53. With sub-irrigation, there is no application loss as applied in the surface or overhead irrigation sense. The circumstances favourable for efficient sub-irrigation are rarely encountered, being an impermeable stratum some distance below the root

zone and a fairly permeable top soil, with level topography. It is difficult to quantify 'efficiency' in this case, as irrigation is effected by artificially raising the water table temporarily. Theoretically, any water not used for evapotranspiration is inefficiency loss, and this is most likely to occur with leakage through the so-called impermeable stratum. It is only with the latest form of sub-irrigation, trickle irrigation, that efficiencies can be very high indeed and may achieve 100%. Regarding buried distribution systems, this is being practised in modern overhead and surface irrigation projects.

54. I feel that although Mr Bulman has put forward some interesting points, irrigation is essentially a field level operation done by practical farmers and it must be operated on a compromise basis in many cases. For this reason, although all research is an advance on current knowledge, there is a practical limit to sophistication if it is to be used in the field. It must also be remembered that many irrigated crops will not economically support a highly refined mode of application.

55. **Mr Awre** reiterates my opinions. His insistence upon a field research element in new irrigation projects is particularly valid, and the facilities allocated often furnish an ideal environment for the extension services to demonstrate improved irrigation techniques to the farmers.

56. I am in general agreement with **Mr Usher**. In his opinion, the aim of new projects should be sprinkler irrigation as the mode of application. However care should be taken to ensure that the environment is suitable for sprinklers. For instance, certain salts in the water such as chlorides may cause leaf scorch, excessive evaporation may occur when sprinkling at a low application rate on very tight soils in a hot dry climate, disease may be encouraged on certain crops. However, fortunately these cases are in a minority, and it does constitute one of the most efficient practical systems now available to the planner.

57. I would like to thank **Mr Edgecombe** for his contribution which stresses the importance of India in the new development of irrigation at that time

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