Efficacy of and Dependence on Tube-Wells as a Means of Providing Additional Supply Necessary for Controlling Salinity and Reclaiming Water-logged Areas

By

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1. The oldest canal system in the United Punjab is the Western Jumna Canal. It was excavated, at first, in the days of Feroze Shah Tughluq in the year 1351. It was abandoned in course of time, and the second construction of this canal was taken up in the year 1568, during the rule of Empror Akbar. The Canal was again restored under British Rule, and the water reached Delhi in 1820. The present headworks of the Western Jumna Canal was constructed during the year 1873.

2. The next canal system is U.B.D.C. which included the Lahore Branch. The construction of U.B.D. canal system was started towards the end of 1850, and it was commissioned on the 11th February, 1859. It started irrigation in 1860-61. This canal takes off from the left bank of river Ravi, in Gurdaspur district (India).

3. The third canal that came into being was Sarhind Canal. The construction of this canal was started in the year 1867, and it was formally inaugurated in 1882. The irrigation from this canal, however, commenced in 1884. The other canals, comprising the great West Pakistan Irrigation system, were constructed gradually in the 20th century.

4. Although the problem of salinity and waterlogging came to the forefront sometime in 1908, the Irrigation Engineers apprehending the rise of the water table as a natural consequence of artificial irrigation, started well observations in 1895. The gravity of the situation was, however, not realized till 1917. The rise in the ground water table continued between 1917 and 1927, and caused some concern to the administration, but nothing was accomplished beyond the creation of the Drainage Board. In the year 1927 the Drainage Board was split into the following two Organizations :

(*i*) Waterlogging Investigation Committee.

(*ii*) Rural Sanitary Board.

5. By the year 1937 the problem had assumed such a serious proportion, that a special waterlogging conference was held under the Presidentship of the Governor of the United Punjab, which was attended by the Ministers,

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Financial Commissioners and the Members of the Waterlogging Board. The Committee thus constituted used to meet once a year to consider matters relating to salinity, and to lay down the policy for the ensuing year. Amongst other methods, suggested for combating the rise of the water table, the excavation of surface drains as a measure of getting rid of flood and rain water, and for lowering the water table level, was considered seriously.

6. In 1932 the Rural Sanitary Board was abolished and the Superintending Engineer incharge of that Board was redesignated as Superintending Engineer Drainage Circle. In 1944 a second Drainage Circle *i.e.*, Northern Drainage Circle was created in the Punjab to expedite the implementation of the construction of new drains and improving the existing drains. After independence the Northern Drainage Circle was abolished as a measure of economy, and the work was distributed amongst the running canal circles and divisions. This arrangement did not work satisfactorily, with the result, that the working afficiency of drains started deteriorating, as the Revenue Circles had no time to devote to this important work of the upkeep of the drains. Consequently, the Drainage Circle was re-established in 1950 and was again closed down in 1953, because the Finance Department considered such organization unnecessary.

7. The Irrigation Department continued pressing for the need and importance of the Drainage Circle, in view of the Government emphasis on providing means of drainage for irrigated areas, that were being affected adversely by the rise of the water table level. The Government, eventually, agreed to sanction the Drainage Circle in 1957. In the meantime the Land Reclamation Board was established to advise on the reclamation operation on the basis of research work conducted to date. To achieve better results, and to cope with the increasing problem of salinity and waterlogging it was considered necessary to establish a separate Organisation under the Irrigation Branch and consequently the Directorate of Land Reclamation was brought into being in 1945. This Directorate, making use of the results of field and laboratory experiments, launched an embitious programme of leaching the saline lands. The operation was limited to areas, where the existing irrigation channels could take additional kharif supplies for leaching such lands. The Directorate of Land Reclamation reclaimed about 4.6 lacs acres of Thur affected areas in the ex-Punjab since its coming into being in 1945.

8. Under this scheme of leaching saine lands, 4,000 cusecs of additional kharif supply was set aside for the reclamation of the affected area. The additional kharif supply thus becoming available is allowed at the rate of 1 cusec for 45 acres, normally for about 3 years, and in special cases for such longer period as is considered necessary.

9. It has, however, been found that the areas thus reclaimed, started

deteriorating within five to eight years of the withdrawal of temporary reclamation supplies. This clearly established the need for continued application of additional supply, which although available in limited quantity (4,000 cusecs) in Kharif, is not available in Rabi at all. In fact, even the small kharif reclamation supply is not dependable, as, at times due to the late rise of rivers in kharif, full use cannot be made of such supply. It has also to be owned that, due to lack of interest and control on the part of those incharge of the reclamation work such supply is frequently misused, by using it on good lands for getting higher yields. This mal-practice could, no doubt, be controlled after reorganization of the Directorate of Land Reclamation has been affected. Moreover, it has also been realized, that as the deterioration of the soil in the ex-Punjab area alone, is of the order of 70,000 acres per year, the effort in the way of temporary reclamation was not commensurated with the rate at which the land was falling out of cultivation. It was, therefore, considered necessary to step up efforts, in this direction with a view not only to check further deterioration, but also to reclaim already affected areas.

10. Realising the gravity and magnitude of the salinity and water logging problem, the Ex-Punjab Government sanctioned the setting up an autonomous Soil Reclamation Board in the year 1952, with a view to effectively control the deterioration of affected areas and to reclaim the areas that had already gone out of production. Since the country's own resources, both financial and in technical know-how, were limited, the Government reached an agreement with I. C. A. for aid in devising ways and means of developing the ground water potential for reclamation purposes. The joint I.C.A. and Irrigation Department Ground Water Development Project, covering the former Punjab area, was launched in 1954, and it took this Organization about four years to complete the exploratory work in Rechna Doab and to compile a detailed feasibility report.

11. Meanwhile, the Soil Reclamation Board commissioned the Chuharkhana Pilot project covering an area of 10,000 acres which included about 3,000 acres that had completely gone out of production. In all 24 tube-wells were installed by the Irrigation Department, for pumping the ground water. The number of tubewells was determined on the basis of additional irrigation supply required for leaching, and not from the drainage consideration. In the first three years of the operation of the scheme *i.e.*, from Kharif 1953 till kharif 1956, some measure of success was achieved, both in lowering the ground water table and in raising the intensity of cultivation in the scheme area (Plate 1 and 2). But soon after Rabi 1956, the intensity of cultivation started declining, touching the lowest of 82% in the 1959-60. The fall in the intensity as well as, yield is the aftermath of persistent high ground water table, which could not be

depleted, as, the recharge from storm water, standing in the scheme area for long periods, and seepage from the Upper Dugara Branch, which has a porous bed in the reach traversing the scheme area, more than off-set the discharge of the tube-wells. The abrupt rise of the water table immediately after every rainfall (Plate 1), proves conclusively the fact that, out of the two sources feeding the ground water, the contribution due to flooding has been the heaviest. Yet another reason for the rise in the ground water table is the intermittent working of tube-wells, due to frequent power shedding in scheme area during the peak load period. The working efficiency of tube-wells, obtaining in the area, averaged between 50 to 55% as against 75% provided in the project.

12. Notwithstanding the set-backs, alluded to in the preceding para, the results of Chuharkhana scheme, in respect of (*i*) increase in intensity of cultivation, and consequently overall yield, and (*ii*) prevention of further deterioration of land (see appendix 1) are quite encouraging. Similarly, the results obtained, up-to-date, in other scheme areas, enumerated in appendix 1, althought they have been commissioned under a year ago, and remembering that it takes anything from 1 to 8 years to reclaim saline areas, they are quite satisfactory. The outstanding success achieved in the Jaranwala scheme area, comprising 85,000 acres, both in respect of drainage as well as step-up in intensity, Plate 3 and 4, is indicative of what could be expected when all the 2200 wells, covering an area of 1.27 M.A. of Rechna Doab go into operation.

13. The foregoing account of the working experience in actual scheme areas clearly indicates that the deterioration and loss of land and crop production, because of water-logging and salinization, can only be arrested and full productivity restored by providing, adequate drainage—both surface and sub-surface by providing surface drains and installing tubewells—and sufficient water for leaching of salts and meeting crop requirements. Since stored supplies are not likely to become available in the foresecable future, the obvious solution, for the area under consideration, lies in tubewell pumping, which can be accomplished expeditiously at reasonable cost.

14. Following aspects of tubewell pumping, which though very vital, do not seem to have been examined in a close and realistic manner :

(*i*) the dependable quantity, and quality of ground water;

(*ii*) the life expectancy and economics of tubewell pumping in areas highly impregnated with injurious salts.

15. In regard to (*i*) above, WAPDA, in their Salinity Control and Reclamation Project No. 1, Rechna Doab, had estimated the quantum of ground water as 2.5 M.A.F. This estimate of the availability of water was not accepted by Messrs Tipton and Kalmbach, Denver, in their review of the project. For, they reckon the ground water yield to be about 1.6 M.A.F. These

conflicting estimates, of quantum of ground water, based on more or less hypothetical approach, are likely to undergo further drastic changes, when corrected for diminution of recharge, on account of reduction of spill and seepage from the river, following construction of storages on rivers in Indus Basin, in Pakistan and India, in another decade or two, at the most, and less soakage of rain water due to provision of extensive network of surface drains, which will ensure speedy disposal of storm water.

16. The Consultants' appreciation of deterioration of quality of ground water—over the period they postulate it will take to lower the water table level to the pre-irrigation level—is not quite realistic, because, the present conductivity index of the ground water—due to presence of local salts in the aquifer—is bound to undergo a change for better or for worse, depending on intensity of salt concentration in the top soil crust, which is going to be subjected to rigorous leaching operations. Since the tubewell supply is usually delivered into existing canal water courses—carrying canal supply—the overall conductivity index, in areas with low concentration of salts, may improve in due course. But in case of areas, with a high concentration of salts in the soil, the overall conductivity may rise to a disquieting degree, necessitating adjustment by curtailing tubewell pumping. This will be inevitable, as, no additional canal water, already fully committed, can be made available for diluting the ground water as assumed by the Consultants in their review. It may also be pointed out in this context, that continued leaching will also deprive the soil of nutritious matter. The deficiency thus arising will have to be made good by extensive use of artificial fertilizer, much more, than was necessary in the past, and partly by following a suitable cropping pattern. The extra cost per acre to Zamindar on this account has to be taken into consideration, if this has not been done already, when assessing the cost-benefit ratio of the tubewell pumping, as a means of providing additional irrigation water.

17. As regards (*ii*) above, the Irrigation Department's experience of working tubewells in the Rasul and Central Tubewell Project areas (about 1500 in number) indicates that, in course of time, as the depression head increases, the discharge declines considerably. In the case of Rasul Tubewells it was noticed that within a matter of 5 to 10 years of the installation of tubewells, their discharge declined from 2 cusecs, to an average of, about 1.4 cusecs *i.e.*, 50% decline, and the depression head increased from 12 ft. to an average of about 17.5 ft. which, of cource, is still less than the designed lift of 20'. Some of the wells, about 20 years old, have registered comparatively high decline in the discharge. In the year 1956-58 the Irrigation Department installed 60 tubewells in D. I. Khan district in the area bordering the right bank of river Indus. These tubewells were commissioned in the year 1958-59. The average

discharge of these tubewells at the time of installation was over 3 cusecs. In June 1962, *i.e.*, three years after the installation, the discharge has again been observed, and it has been noted, with concern, that the average discharge of the tubewells has declined by about 14% (average). Another disturbing feature of the D. I. Khan tubewells, although located within short distance of river Indus, is that whereas the salinity index at the time of installation was between 300 to 700, it has risen to an alarming degree in certain cases. As a result, some of the tubewells, have been stopped and we are thinking of pulling out of the strainer and the blind pipe, because, the water pumped by these tubewells is not fit for irrigation purposes.

18. The majority of Irrigation Department tubewells have the following specifications :

(*i*) Brass strainer 7¼ to 10′ dia, 100 to 180′ long and 5 to 8% open area;
(*ii*) Shrouding 4 to 5″ thick;
(*iii*) Wells are fitted with centrifugal pumps;
(*iv*) Depression head assumed to be 12 to 20′;
(*v*) Designed discharge 2 cusecs.

WAPDA, who are installing about 2,000 wells in the Project No. 1 area, have changed the design of tubewell strainer and adopted the following specifications :

(*i*) Iron Strainer 10″ dia, 100 to 150′ long and 8 to 10% open area; (wider slots)
(*ii*) Shrouding 6″ thick;
(*iii*) Wells to be fitted with deep well turbine pumping sets;
(*iv*) Designed discharge 3 to 5 cusecs.

19. These wells are comparable to the Irrigation Department A.T.W. wells, appendix III item 17, where the discharge declined by about 12.5% and the depression head increased by about 100% within a matter of six months of the commissioning of the tubewells. Although the decline in the discharge, varying from 12 to 30%, would not be of any serious consequences in case of WAPDA tubewells, considering that their tubewells have about 40% reserve capacity, notice has got to be taken of (*a*) the sharp increase in the depression head, and (*b*) the life expectancy of the tubewells.

(*a*) The Consultants postulate that withdrawal from the ground reservoir, at the rate of 0.4 A. F. per gross acre annually (in excess to the recoverable recharge), would deplete the water table by 1.25′ per annum, and take it back to the pre-irrigation level—average 40 to 60 ft. below natural surface—in about 40 years, which incidentally is the life expectancy of tubewells assumed in Project No. 1.

20. According to accepted concept, the percentage of the moisture carried by the free water table zone is 40%. The yield of about 10% from

this zone will create capillary fringe, and lower the water table by about 1.0 foot. Thus, for a yield of 0.4 A.F. per gross acre per annum, the depletion of the water table would be of the order of 4.0 feet per anmum. This estimate of the depletion of the water table by the Irrigation Department seems to be more realistic than the rate of lowering of 1.25 ft. visualised by Messrs Tipton and Kalmbach, and finds support in WAPDA's recent claim—in its Weekly dated 26th October 1962—to the effect that the water table in the Rechna Doab has been lowered by 3.67 feet since the commissioning of the tubewells in that Doab. From this it would follow, that the lowering of the water table to pre-irrigation level of 80 feet (average) could be effected in 20 years instead of 40 years assumed by the Consultants in their project. In other words the economic pumping limit of 40 feet pumping head would be reached in 10 years, and that, pumping beyond that peiod would be uneconomical.

(*b*) The Irrigation Department similarly would be reluctant to accept WAPDA's estimate of life expectancy (40 years), depending on the discharge, and consequently the financial forecast of salinity and reclamation project. This contention of the Irrigation is based on the working experience of tubewells installed in the various scheme areas, *e.g.*, 30 tubewells, installed along Upper Chenab Canal-forming part of the Rasul Project and sanctioned in 1945-46—had to be closed after about 8 years working due to uneconomical yield. In order to ascertain the causes of the decline in the discharge, the strainers and blind pipes of some of these wells were recovered and it was found that a thin layer of incrustation—on the inside of the strainer—had completely blocked the strainer slits. Incidentally, the conductivity index in this area is of the order of 500 to 800. There are also instances of heavy incrustation of the strainer in the case of some of the tubewells installed in the Chaj Doab. The incrustation in this case is, so heavy and hard, that it could not be removed from the strainer with light hammer blows. The maximum conductivity index in this case, of course, is of the order of 20,000. In cases of this type where the ground water will have to be pumped for drainage purposes, some special salt-resistant alley will have to be evolved for getting over the trouble of incrustation.

21. From the above discussions, it clearly emerges that till such time as the outstanding controversial issues, like yield of aquifer, depletion of water table, cost of pumping and other allied matters, like the action of salts on the tubewell machinery, have been resolved—on the basis of working experience of Project No. 1 Rechna Doab, to the satisfaction of all concerned—it would be advisable to go slow with the implementation of WAPDA's Salinity Control and Reclamation Project No. 2 Chaj Doab. The minimum test trial period, necessary for obtaining reasonably reliable field results in the area covered

by Project No. 1, would be about three years, which incidentally conforms to the lower limit of reclamation period. This suggestion may not be received well, in certain quarters, considering, the high priority and importance the present Government atttaches to this No. *One* problem of the country, and bearing in mind the President's recent directive regarding curtailment of the completion period of reclamation and drainage programme from 15 years (envisaged in WAPDA's overall programme) to 10 years. It could also be argued that as soil texture, and hence the permeability, varies from Doab to Doab, and oven within Doabs, the results obtained in Rechna may not, strictly speaking, be truly applicable in the Chaj Doab. This may be so, but it is nevertheless felt that such an approach, besides reducing the margin of calculated risk, would be more realistic than the approach in WAPDA's project. In actual fact, it is not proposed to suggest the with holding of implementation of Project No. 2. What is suggested, is, that instead of starting work simultaneously on the installation of tubewells and the construction of drains, it should be so staggered that the field trial period of three years is utilized for constructing the drains, and the installation of tubewells is postponed till after that period. By the end of that period, it is hoped, sufficient working experience of the tubewells, in Project No. 1 area, would have been gained to indicate whether or not any modification in Project No. 2, in so far as tubewells are concerned, is necessary. This rephasing of the project is fully justified, considering that whereas it will not seriously impede the tempo of drainage and reclamation programme, it might save us the embarassment that may have to be faced in case the assumptions made in the Project do not conform to the field results.

22. The above recommendation, if it is at all accepted, would not in any way, affect the tempo of implementation of WAPDA's drainage and reclamation programme in areas, where measures other than tubewell pumping may have to be adopted. For instance, in vast areas of southern zone of West Pakistan, like G. M. Barrage and part of Sukkur area, where the conductivity index of the ground water is such that it cannot be used for irrigation, or leaching purposes, the ground water will have to be pumped or drained for depleting the water table. The task, of suggesting ways and means of (*i*) preventing rise of water-table and salinization in G. M. Barrage area and part of Sukkur area, where soil deterioration has not started as yet, and (*ii*) reclaiming already salinized areas and lowering the water table, has been entrusted to Messrs Hunting Technical Services Ltd. by WAPDA, who have been charged with the proparation of an overall plan for drainage and reclamation of the area.

23. The Consultants have already submitted a preliminary appraisal

report, covering G. M. Barrage area, with specific reference to Gaja area where conditions in regard to both rise of water table and salinity effect are pretty serious. The Consultants had suggested in their earlier report that the Irrigation Department storm-cum-seepage gravity drains should be converted into seepage drains as the former are not likely to be very effective. The Department, on the other hand, experienced—and are still experiencing—serious difficulties in getting to the designed bed levels of shallow drains in high water table reaches. They, therefore, are not very optimistic of the success of deep seepage drains, which would be difficult to construct and costly to maintain, due to heavy side and bed sloughing. They are, therefore, instead of trying to experiment with draining the area by tubewells, which too have, up-to-date, not given very satisfactory results, in that, four out of seven wells stopped functioning after a year. The experiments are, however, being continued and it is a little premature to judge the results on the basis of inadequate studies available at present. The Department also intends to attempt drainage of the ground water table by means of (*i*) shallow open percolation wells, and (*ii*) tile drains in areas where the water table is high. The results of these experiments would become available in due course, when it would be possible to decide which of the four measures viz : (*i*) deep seepage drains; (*ii*) tubewells; (*iii*) shallow open percolation wells; and (*iv*) tile drains would be more effective and economical. In fact, it is possible that different devices may have to be used in different areas of the southern zone depending on the conditions obtaining there.