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WATER CRISIS IN PAKISTAN AND SOLUTIONS

by
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ENGR. FATEH ULLAH KHAN*

PART-I

Canal System Based on Run-of-River Creates Water Scarcity.

The seasonal scarcity of water is inherent in irrigation system based on the erratic run-of river. Consequently, seasonal water crisis in Pakistan is the result of highly fluctuating and uncontrolled river flow wasting about 35 maf of water as flood flow to sea each year. Moreover, about 52 maf of surface water is lost due to seepage from the unlined canal irrigation system. The total loss of surface water comes to about (35+52)=87 maf or 60 percent of the whole i.e. of 142 maf. The solutions to avoid wastage of water that cause scarcity lie only in the Integrated Comprehensive Water Management (ICWM) of 142 maf of surface water with one of its vital and integral component of storage dams. (Definition of (ICWM) attached).

Agricultural practice is no longer an ancient art still practiced in under developed countries, but now for the whole World, it is a modern science - the science of survival. We must therefore switch over to increase efficiency of water use by modernizing our monoculture, rigidly supply based, unlined and wasteful canal irrigation system for our survival. This needs minimizing the colossal wastage of water due to floods and seepage and by regulating the erratic flow of river Indus by building storage dams. This is necessary to meet shortage of water and enhance agricultural productivity. In winter, there is acute scarcity of water as the run-of-river discharge of the Indus falls extremely low that direly needs floodwater storage.

Scarcity of water due to the incompatibility of Lacy's Regime flow canal.

Pakistan has inherited the World's largest, contiguous, unlined canal irrigation system based on run-of-river about 150 years ago. The canal was designed on Lacy's empirical formula basically to maintain regime flow conditions for a stable non-silting non-scouring canal with a constant and fixed discharge, a given bed slope and a given cross-sectional area. To support these rigid hydraulic parameters, compatible agricultural parameters of monoculture were adopted by fixing Kharif and Rabi ratio of 2:1, with 60 to 70 percent intensity of irrigation. These parameters were primarily assumed in an effort to equate canal discharge between Kharif and Rabi crops mainly for the design of the canal to have a fixed and constant discharge for the sake of maintaining regime flow of non-silting and non-scouring. The extremely erratic flow of the Indus that fluctuates nearly in a range of (100:1) during summer and winter was also kept in view while adopting agricultural parameters.

Consequently, with the passage of time, agricultural parameters changed and improved with progressive development of agriculture to get enhanced productivity. It was therefore no longer practicable to stick to monoculture practice and to enforce fixed and constant discharge as originally assumed and adopted for Lacy's canal design. As a necessity of circumstances the changes in agricultural practice to grow water insensitive crops to achieve greater productivity and economic benefits led to the change of hydraulic parameters of the canal design that affected its stability or regime flow conditions of non-silting and non-scouring. Thus instead of monoculture practice, a multiculture practice was progressively developed for economic gains by adopting high cropping intensity and a changed Kharif and Rabi ratio. The farmers realized to get the best possible use of land and water interaction for getting more income per acre. The new situation created increased water demand that could not be arranged in a rigid regime flow canal system due to canal capacity

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restraint and lack of storage. This created canal flow incompatibility with crop water needs during the keen demand period that result in scarcity of water. Besides this some inundation canals in the Indus basin become perennial that required additional water and created scarcity in winter. The rapid change in intensity of irrigation and cropping pattern required more water that changed the originally adopted hydraulic conditions. As a result of these basic changes as originally assumed in the canal design the hydraulic equilibrium or the regime flow conditions for the Lacy's canal drastically changed. This caused the silting of canals, reduction in canal capacity and its discharge that led to shortage of water creating crisis and water disputes. Under the circumstances as explained above the silting of canal and reduction of its capacity indicates failure of the originally conceived fixed discharge canal irrigation system as it can not meet the changed crop water needs for developing agriculture. It is amusing that the failure of canal in the form of silting is celebrated each year with fervor of ritual ceremony without feeling that it shows its failure, as it no longer remained the Lacy's canal.

The canal system based on run-of-river suffers from shortage of water during the low flow reason in winter as the Indus river discharge falls as low as 10,000 cusecs against the summer maximum discharge varying approximately between half a million cusecs to a record discharge of one million cusecs. Under the changed circumstances it is not possible to meet crop water needs from the Lacy's rigid flow canal that is not required to run in fluctuating order simply to maintain its regime. Due to the developing agriculture and higher intensity of irrigation i.e., up to 170 %, the canal need greater supply of water for crops in fluctuating order ranging in a ratio of (4:1) between the maximum and minimum demand that creates scarcity of water. The solution to the scarcity of water lies in modernizing the existing supply-based canal system to a demand based system. This is necessary to carry water as and when required for crops and needs to build storage dams to support canal system. Dams are urgently required to regulate the Indus flow as presently about 35 maf of floodwater is wasted to sea. Tarbela and Mangla have already lost about 6 maf of their gross storage capacity and the remaining about 12 maf of live storage is not enough to meet the scarcity in water as 50% of the storage water is lost in wasteful canal conveyance system. The losses of water in the Indus bed are in addition.

It is established that due to agricultural development the Lacy's canal under went transition that made it incompatible to carry water to match additional crop water needs. As such, the canal became obsolete for practicing modern and profitable irrigated agriculture with high intensity of irrigation and for growing water intensive cropping pattern that requires fluctuating discharges. The Lacy's canal therefore requires replacement by a canal to carry fluctuating discharges with a maximum to minimum ratio of (4:1) to meet greater crop water needs as required. A fixed discharge canal wastes water at times when water is not needed by crops.

Removal of scarcity of water needs replacement of unlined canal system by Lined.

There is dire need for systematic change to replace the monoculture, unlined, obsolete, supply based, incompatible rigid flow irrigation system that wastes 50% water in its conveyance system as seepage losses. The huge seepage losses create scarcity of water besides drainage hazard. Moreover, it is not practicable to maintain Lacy's canal section unchanged. The need is therefore to design a lined canal on Manning's formula to avoid and minimize huge wastage of about 52 maf of seepage water. The additional advantage of lined canal is that it would carry silt to the field and avoid cost of annual silt clearance and disruption of water supply. The water requirement of developing agriculture is that it needs more water in winter and so in summer. There is of course scarcity of water during winter due to lack of storage where as in summer the canal capacity becomes a restraint to cause shortage of water.

Some of the causes for the scarcity of water due to the conveyance system can briefly be concluded that Lacy's canal remained no longer compatible to meet the increasing demand of water as per crop consumptive use due to fast progressing agricultural activities. High intensity of irrigation and profitable water intensive cropping pattern has taken over. This made the existing canal

obsolete. This needs a lined canal system with the support of huge storage dams to run water in fluctuating order as per demand ranging in a ratio of (1:4) between the minimum crop water needs and maximum need. This ratio was observed on upper Swat canal in 1973 while doing research. This requires a demand based canal system as the present water needs of developing and profitable agriculture by the supply-based canal are beyond the design capability of Lacy's regime flow canal. Moreover, the canal system is most inefficient and highly wasteful causing scarcity of water and is incompatible with the fluctuating water needs of agriculture.

Wastage of 52 maf of water from unlined canal system - the major cause of scarcity of water and a great drainage hazard.

The existing Indus Basin Irrigation System (IBIS) was drawing 80 to 85 maf of water on run-of-river before Tarbela and Mangla dam. After the storage it diverted about 103 to 105 maf of water out of the total surface flow of about 142 maf on the average. On diversion of 103 to 105 maf of water into the Indus basin canal system and its one million miles of watercourses, about 52 maf of water equal to about 10 times the storage of Basha dam is lost in seepage and other waste flow. This waste flow has become the drainage effluent in the form of groundwater that created salinity, sodicity and waterlogging. At the same time the huge wastage of 52 maf of surface water and the increasing need of water for intensive agriculture has created water scarcity and water crisis that led to provincial disputes. Surprisingly, no sub- surface drainage system was provided as a component of the irrigation system. The Lacy's unlined and seeping irrigation system was left incomplete by ignoring drainage system that also forms the integral component of Water Management. (See definitions attached). Drainage is essentially needed to physically evacuate saline and saline sodic drainage effluent from the root zone area of crops to control salinity and waterlogging and maintain salt and water balance. Before undertaking drainage project, the drainable surplus has to be reduced to the minimum possible limit to reduce the cost of drainage and to save waste flow from canal system. The blocked drainage effluent has affected about 60% of land to various degrees by salinity; sodicity and waterlogging that resulted in one of the lowest crop yield per acre in the World.

A wasteful canal irrigation system that loses 50% water enroute and creates drainage hazard adversely affecting agriculture can straight away be declared as obsolete. The existing waterlogging and salinity caused by heavy seepage is a curse of the unlined and obsolete Indus Basin irrigation system. It has done more harm than good. It is warned that the stored water from the future dams and reservoirs to be created at very high cost would be of little use if 50% of it is going to be lost due to seepage from the existing system. Moreover, the loss of water in the 14 miles wide and hundreds of miles long meandering Indus River bed is estimated by IRSA to be about 14 maf. This is an additional water loss in conveyance.

The long distances of wide based, unlined canal irrigation system with low velocity of water and passing through arid region with high temperature loses more than 65% of its flow in conveyance before reaching the field from Chashma to Kotri barrage system. There is therefore a great need to avoid these huge conveyance losses in canal system in the Indus River to remove water crisis in Pakistan and also to cater for the future needs of the fast growing population.

Loss of storage capacity due to silting of reservoirs

Tarbela dam, Mangla dam and Chashma barrage added a live storage of about 16 maf of water to the existing irrigation system about 30 years ago. This stored water accelerated the development of irrigated agriculture but now the scarcity of water is caused as Tarbela and Mangla have lost about 6 maf of their gross storage capacity. The scarcity of water is being perpetuated, as the storage lost is not replaced by a new dam even after 28 years after Tarbela. It needs immediate replacement to avoid more scarcity. The short-term and quick solution to the scarcity of water only lies in building Katzarah dam with a storage capacity of 35 maf on the Indus. This dam will solve many serious water and power issues. The diversion and use of stored water in the existing wasteful canal irrigation system by itself is a serious problem as 50% of the storage water is wasted

in seepage. For example, a medium size storage dam like Basha will lose about 2 maf of water out of its 4 maf of live storage before it reaches Guddu and Sukher barrages. Therefore, a huge storage like Katzarah dam reservoir can only help even after seepage losses in conveyance system as it has more than 6 times larger storage than at Basha. A short-term solution to remove scarcity of water other than Katzarah dam would be a miracle by nature if it melts the snow.

The ultimate solution to scarcity of water lies in Integrated Comprehensive Water Management.

In fact, there are multidimensional problems that have resulted in water scarcity and its crisis in Pakistan that need both short- term and long- term solutions immediately. The water crisis and drought have resulted in famine, death, devastation, migration of population and cattle and even in the sale of daughter by a severely affected person in Baluchistan that shows extreme human distress, helplessness and misery simply because of the scarcity of water specially in less developed parts of Pakistan. The scarcity of water has adversely affected irrigated agriculture in the Indus basin and has blocked future development to meet the needs of multiplying population. The very basic cause for the scarcity of water is lack of Integrated Comprehensive Water Management (ICWM) that consists of many processes of its various integral and vital components to avoid all wastage of water, conserve it and use it efficiently by providing proper infrastructures. The ICWM provides for river regulation by building storage dams to control floods and waste flow to sea. It provides efficient demand based canal irrigation system and to adopt waste free water distribution methods. Moreover, Water Management also provides for scientific application of water to crops at proper time in proper dozes and the removal of excess water and salts by surface and sub-surface tile drainage from the fields to promote increased agricultural production. These integrated Water Management measures are to be collectively adopted to remove scarcity of water as long- term measure for sustainable irrigated agriculture. Water Management can only be successful if done comprehensively with all its integral components as given in its definition.

Major sources of water wastage to be handled to reduce scarcity of water.

The following are the major sources of wastage of water that has created water crisis in Pakistan. It needs short and long-term solutions through ICWM with excellent professional governance in the context of National Water Policy that is still awaited.

1. **Flood Waste**

It is highly essential to minimize the loss of about 35 maf of floodwater going waste to sea each year. This needs a huge storage dam with a storage capacity of 35 maf as available at Katzarah as a solution to the scarcity of water. The building of a single dam long over due is comparatively short-term solution if looked in the context of ICWM that would handle all complexities and problems.

2. **Seepage losses from canal system.**

There is dire need to minimize the loss of 52 maf of seepage water from the unlined, supply based canal irrigation system by replacing it by a lined demand based system. Moreover, the Warabandi practice is to be replaced by crop consumptive use for the supply of water to crops. At the same time, flooding method of irrigation be replaced by more efficient methods. There is dire need for (ICWM) of the total available surface water of about 142 maf. This is a complex and long-term permanent measure to remove scarcity of water. To understand correctly what Water Management, Irrigation, Drainage and Leaching require can be observed from their technical definitions as attached. Generally their true concept is not picked up while project planning and their execution. The result is failure of projects as is the case of SCARP, the NDP, the storage projects, the irrigation and Water Management projects during the passed 40 years. For clear understanding, their true definitions are attached as enclosure.

3. **Water losses from the Indus bed.**

It is necessary to minimize the seepage losses of about 14 maf of water from the bed of river Indus. This huge loss of water as reported by IRSA is due to the 14 miles wide and about 1000 miles long meandering Indus River course. In order to reduce seepage as well as evaporation losses and also to help remove scarcity of water, the Indus River channelization is very necessary. This will also yield many other benefits like huge land reclamation on both sides of the river that could be about six million acres of very fertile land. It will also create navigation facilities etc. Indus River channelization will become very easy after the building of Katzarah dam as that will fully control floods and regulate the flow of the Indus as required for channelization. It will save huge seepage and evaporation losses of water enroute due to the reduced wetted parameter and smaller water surface area of the channelized river. This will be a long-term measure. The reclaimed land of about 6 million acres along the riverian area can be given to foreign firms for modern cultivation. This can fetch about Rs. 400 billion on very low estimate.

WATER CRISIS IN PAKISTAN

PART-II

Short- term solution

Short-term solution to remove scarcity of water is to immediately build the Katzarah dam on the Indus to store 35 maf of floodwater going waste to sea that is six times the storage of Basha dam. It will generate 15000 MW of power having a life span of about 1000 years due to negligible silt and excellent capacity- inflow ratio at this site. The dam will regulate the entire flow of river Indus. The long-term measures to remove scarcity of water can be taken through ICWM to further reduce the colossal wastage of water due to the unlined, traditional irrigation system. The losses in the Indus River bed can be reduced after the building of Katzarah dam and the channelization of river Indus.

The aggregate wastage of 87 maf of waters i.e. 60% of the whole.

The awful wastage of about 60% of the surface water is in the knowledge of the Govt. but still due to bad governance by non- professionals and the charlatans policy makers, the chaotic conditions of the scarcity of water is being perpetuated for years. It is not brought to the notice of the President. Things have now nearly reached the point of no return. The major losses and wastage of water due to the three main causes as stated above are further analyzed. These need prevention, control and conservation by undertaking (ICWM) as per its technical definition attached. This will be long- term measure.

The total major losses due to the unlined irrigation system, flood waste and losses in river Indus comes to about (52+35+14)=101 maf. If river bed "losses and gains" are ignored, then the two major losses due to seepage from canal system and flood waste comes to (52+35)=87 maf out of the total surface flow of about 142 maf. This loss of water is 16 times the storage capacity of Basha dam. As Pakistan lacks good dam sites on the Indus to store water, except Katzarah site, the best alternative would be to eliminate most of the seepage and flood losses of about 87 maf of water and adopt sprinkler and drip irrigation methods as far as possible. This will permanently remove scarcity of water.

The huge losses indicate that the net surface water available for irrigation at the farm in the Indus basin is only about 55 maf out of 142 maf and the rest is lost in conveyance systems and floods. Besides this, to our good or bad luck, about 45 maf of the blocked saline drainage effluent as ground water is recovered by 585000 small private tube wells in Punjab at a great cost of pumping.

This highly injurious drainage effluent, in violation of the Canal and Drainage Act of 1987, is reused on lands to the ultimate detriment of irrigated agriculture. It is estimated that about 70% of the pumped drainage effluent from the ground are saline sodic that would in the next about 20 years render most of the Indus basin as saline waste. Adding the 45 maf of the drainage effluent as injurious saline groundwater, the total fresh and saline water consumed by the farmers in the Indus basin comes to (55-45) = 100 maf. This water is nearly consumed by about 28 million acres of land in the Indus basin, as some lands are "disaster areas". On this basis the average delta of water comes to about 3.57 ft or about 43 inches. In some areas, the recorded delta of water was more than 4.5 times this figure on some canals.

The following measures as integral parts of ICWM are summarized for the solution of water scarcity.

1. The principle to build dams on a river for irrigation, power generation, river regulation and control and navigation etc in many countries of the Word is to create storage reservoirs "equal to 1.6 times the average annual flow" at a given site. Some countries have created storage equal to 4 times the average annual flow. By doing so maximum benefit from the national water resources is obtained. Taking the average annual flow of river Indus as 60 maf up stream of Tarbela, we are then required to create about 96 maf of storage to make the best use of Indus River water. Against this, we have only a fast depleting storage of about 7.5 maf at Tarbela. Therefore, to remove scarcity of water, it is direly essential to build Katzarah dam on war footing as its storage capacity is equal to six times the storage of Basha dam. This is the best short-term measure in the over all ICWM process to over- come shortage of water. The Pakistan Engineering Congress may approach the President to build Katzarah dam without further loss of time as raising Mangla to create a meager storage of 2.9 maf can not solve the serious problem of scarcity of water as 6 maf of storage at Tarbela and Mangla has already been silted up.

2. To replace the unlined, seeping, rigid flow, monoculture, supply based, and incompatible canal irrigation system by demand based lined canal system. This will reduced the greatest wastage of water of about 52 maf to the minimum. To begin with, a demand based irrigation system needs the prior support of a huge storage dam like Katzarah with storage capacity up to 35 maf on the Indus. The other dams can follow. Sooner or later it has to be done, as this is the permanent solution to remove scarcity of water. These measures form integral components of ICWM. Seepage from canal system is the single and the largest source to waste water equal to about 10 times the storage of Basha dam. Therefore, it has to be minimized and avoided.

3. The second major wastage of water is the 35 maf of flood waste on the average to sea each year. This is more than 6 times the storage of Basha dam. This also needs the construction of Katzarah dam for storing flood waste. Katzarah too has maximum storage capacity of 35 maf. Storage dams are vital parts of ICWM.

4. The third major loss of water of about 14 maf equal to about 3 times Basha dam is due to seepage from Indus River bed. To minimize the excessive loss of water from the 14 miles wide, a 1000 miles long and meandering Indus River bed will need channelization. Once again, to do this, the construction of Katzarah dam is pre-requisite as river channelization need it. This form part of the ICWM.

5. The 28 years long storage controversy of Kalabagh dam due to its faulty hydraulic design and the avoidable delay has created scarcity of water and water crisis in Pakistan. A purely technical issue has been made political due to WAPDA's mishandling of the storage projects. This was because an unsuitable site with a wrong project concept and with poorest-capacity- inflow ratio was pre- fixed by WAPDA in the Term of Reference (TOR) of the Consultants. Due to this restraint imposed on consultants and on account of mid-level

restricted sluicing, the hydraulic design of the dam was flawed, as it can not remove silt out of the reservoir at Attock. The TOR did not allow the consultants to select the best possible dam site on the up stream of the Indus after Tarbela to have long life span and excellent service value. WAPDA's cry for storage is specific to Kalabagh dam and has become its motto. For this very reason, WAPDA's vision-2025 does not include to build a mega dam on the Indus for the next 25 years. A dam will take about 10 to 15 years to build, this means WAPDA has no intention to build a mega dam for the next about (25+15)=40 years though ICWM requires it as its integral components. Such obstinacy is not in national interest when the nation is facing drought, famine and extreme crisis of water that leads to permanent disputes and hatred between the provinces. The only and the short-term solution to the crisis of water is to build Katzarah dam rapidly and dramatically. This should be placed on top while preparing the National Water Policy. Due to hydraulic deficiencies in the design of Kalabagh dam that would cause rapid silting of its 3.5 maf direct storage at Attock, the IRSA rejected Kalabagh dam design on 22-10-1996 with 4:1 majority and informed all concerned. On the basis of restricted mid-level sluicing design, a dam at Sanmenxia in China had already failed. WAPDA should learn a lesson from others mistakes rather experiencing itself. Under the circumstances as explained above, the serious situation of water shortage urgently requires a drastic change in the inert attitude of all concerned to effectively deal with the scarcity of water.

6. The existing supplied based canal irrigation system either performs over irrigation or under irrigation by flooding method of uneven plots. Both these conditions are bad for crop yield. Besides this, over irrigation waste a lot of water. Water supply to crops is based on land area in hours, called " Warabandi". This also leads to over or under irrigation. Water should be supplied on crop consumptive use basis. These traditional practices are the source of wastage of water that causes scarcity of water. These need rectification as part of ICWM by modernizing the canal system. Proper and efficient water application methods should be adopted so that water is not wasted beyond the root zone of crops that create drainage hazards as well as scarcity of water.

7. Most of our land under irrigation is uneven and the plots are irregular in shape. These need land leveling, land reform and land consolidation so as to bring them in proper rectangular shape for the efficient use of water. These measures are the prerequisite of ICWM.

8. One of the revolutionary steps to improve irrigated agriculture and save water would be to replace the one million miles of the highly wasteful watercourses by "pipe supply". This will avoid wastage of about 30 maf of water equal to 6 times the live storage of Basha dam. The "pipe supply" system will eliminate seepage and evaporation losses besides avoiding theft of water. This system forms vital component of ICWM and is practiced throughout the developed countries. This will greatly help in removing the scarcity of water.

9. There is an urgent need for the adoption of sprinkler and drip or trickle irrigation methods as for as possible to avoid scarcity of water. The sprinkler irrigation uses $1/3^{rd}$ to $1/5^{th}$ of water as by flood irrigation method. The drip irrigation method uses water of about 10% of the flood irrigation method. These water application methods would bring revolutionary economy in water use and help avoid water crisis in Pakistan. This forms part of ICWM.

10. A permanent solution to water crisis in the Indus basin lies in the implementation of ICWM of 142 maf of surface water along with all of its integral components, like storage, drainage, efficient conveyance and distribution system and the efficient methods of water application to land. For knowing technical definitions of Water Management and its integral components, please refer to the definitions as attached.

11. For practicing sustainable irrigated agriculture there is the need for two important factors. The one is adequate and assured water supply and the other is proper drainage of the root

zone area of crops to maintain salt and water balance. The principle in executing drainage project is first of all to reduce the drainable surplus to its minimum so as to save water and also save cost of drainage by reducing the drainage effluent. The ICWM includes all these measures; therefore it must be given top priority to reduce the 60% surface water losses or 87 maf of water wastage to the minimum possible limit. This will provide a permanent safeguard to ensure water availability throughout the year.

12. There is no doubt that the problem of scarcity of water is due to the mismanagement of our national water resources as we are wasting 60% of the total surface flow of 142 maf. Therefore, efforts must be made to minimize and save this colossal wastage of water to remove scarcity and water crisis. If we do that, then there should be no fear of any interference in water resource from across the border. If the above measures to avoid losses were seriously taken in hand, we would be self sufficient in water to permanently irrigate a total area of about 60 million acres of land i.e. nearly twice the area now irrigated. This is only possible through ICWM.

13. Above all, the easiest possible source for removing water crisis lies only in building Katzarah dam dramatically and rapidly to end water and power woes. There is no short- term, technically sound and most effective solution to water crisis other than the building of the three gorges 35 maf storage dam on the Indus at Katzarah. The unique dam will serve as pivot to implement ICWM. The power generation from the dam is tremendous that will help modernize irrigation system. The President has urged many times for a very big reservoir but unfortunately he is not informed that Katzarah is the largest reservoir in the World.

Series of dams-cum-barrages on the Indus to remove scarcity of water and power.

There are no good dam sites short of Katzarah and Basha above Tarbela on river Indus. This is due to the poor capacity-inflow ratio, smaller storage capacity of reservoir, rapid silting and short life span. All storage dam sites are poorer in capacity than Basha due to narrow valley of the Indus. But still we have to harness the water and power resources of river Indus to remove scarcity of water as well as of power and specially to avoid rapid silting of reservoirs for our economic survival. Therefore new concept of a storage-cum-sluicing structure consisting of a combination of dam-cum-barrage on silty river Indus at suitable interval is proposed between Tarbela and Basha in a length of about 280 miles. Even Kalabagh site at the end of the valley can be considered for such a storage-cum-sluicing structure. The new concept is to build a concrete overflow gravity dam up to the proposed dead storage level. Over the crest of the dam, a conventional barrage with unrestricted sluices and with a waterway to pass maximum flood discharge with free flow should be constructed. About 60 feet barrage would create a live storage from 2 to 3 maf of water depending on the storage site. This storage created by the unrestricted sluicing barrage will never silt. It will be a sort of raised barrage especially suitable for construction in the narrow river valley. It is analogous to Chashma barrage with the function of silt sluicing and in creating storage. Giving example of Kalabagh dam, a concrete gravity over flow types dam can be constructed up to R.L. 830. This will have a height of (830 – 680) = 150 ft up to the dead storage level. Over the top of concrete dam, a 60 ft high conventional barrage with unrestricted sluices to freely pass maximum flood flow can be constructed. This will create a live storage of about 3.5 maf at Attock and on the Soan River combined. This is the only solution to avoid silting in narrow river valley. There is about 7000 ft fall with in about 280 miles on the Indus that can be used to produce power of about 30,000 MW and a storage of about 25 to 30 maf of water. This will remove scarcity of both water and power. In case of Kalabagh site it would be more costly due to the long length of the dam if compared to the up stream narrow valley sites.

WAPDA's myopic vision of flood canals to create grave scarcity of water.

The WAPDA's myopic vision 2025 programme of flood canals namely Thal canal, the Kachi canal, the Raine canal, six canals from Sehwan barrage and Thar canal will cause great water

shortage and severe water disputes if water in these ten flood canal systems is allowed to flow for more than 70 flood days in a year of 365 days. Their aggregate discharge is about 30,000 cusecs or 21.5 maf of water to be made available at their Head Works. Allow 50 per cent wastage of water in conveyance systems, the total water requirements of flood canals comes to 45,000 cusecs or 32.3 maf of water. This means WAPDA is building network of flood canals either to sow the seeds of disputes and hatred between the provinces or simply to abandon the network of flood canals wasting billions of rupees. The flood canals would be of no use prior to the building of Katzarah dam with a storage capacity of 35 maf. Moreover, prior arrangement for the efficient use of water by avoiding huge wastage of 87 maf of water through the process of ICWM is absolutely vital. These are the only basic sources to make more water available to run flood canals perennially and to meet the present acute shortage of water for the existing irrigated areas.

The question is how would it be possible to restrict flow in flood canals for 70 flood days only in a year of 365 days? The building of flood canals will add one more failure to the series of failures of SCARPs, NDP, the storage failure due to controversy, and the water and power crises etc. There is a vital need to immediately revise the present schemes priority-wise in the vision 2025 programme before it is too late.

(A) Definition of Irrigation.

"It is defined to include irrigation, drainage and flood control all of which relate to the moisture control of crops in the filed".

(B) Definition of Drainage.

Drainage is the essential part of irrigation works, collecting the water that leached the salts out of soil and evacuating it out side the area, as well as separating the "reclaimed layer" from the sub-soil to avoid raising the water table with the resultant retrogression. Drainage prevents a rise in water, keeping the later at a depth that will not harm root development and maintain salt and water balance".

Note: - SCARPs and NDP were not designed to provide sub-surface tile drainage as per its definition. Therefore they failed.

(C) Definition of Leaching.

"Leaching is the process of dissolving and transporting soluble salts by downward movement of water through the soil".

Note: -{Definitions of Drainage and leaching clearly indicate to provide surface and sub-surface tile drainage to carry away the dissolved drainage effluent out of the area to protect roof development. SCARPs and NDP have no such sub- surface drainage component; therefore they are complete failure}

(D) Definition of Integrated Comprehensive Water Management (ICWM).

"Water Management is defined as the combined processes of storage, diversion, conveyance, regulation, measurement, distribution and application of the rational amount of water at proper time and removal of excess water from the farms to promote increased production economically, in conjunction with improvement of agricultural practice and institutional arrangement".

Note: - The definition of ICWM clearly shows that it is the integrated process of all of its components to avoid all wastage of water as well as to physically remove excess salts and water by drainage of the root zone of crops out of the area and adopt water efficient agricultural practices.