The Irrigation Management Strategy for Irrigated Agriculture of Sindh Province (Pakistan)

Project Coordination & Monitoring Unit
Sindh Water Sector Improvement Project

Planning & Development Department
Government of Sindh
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# Issues & Revision Record

<table>
<thead>
<tr>
<th>#</th>
<th>Date</th>
<th>Originator</th>
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<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
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<tr>
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<td>D</td>
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</tr>
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<td></td>
<td>Review and Comments</td>
</tr>
<tr>
<td>G</td>
<td>July, 2015</td>
<td>Umer Karim (UN-FAOPK)</td>
<td>F. V. Steenburghen</td>
<td></td>
<td>Review and Comments</td>
</tr>
<tr>
<td>H</td>
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<td>Noor M. Memon, Umer Karim (UN-FAOPK)</td>
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<td>Review and Comments</td>
</tr>
<tr>
<td>I</td>
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<td>Umer Karim (UN-FAOPK)</td>
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<td></td>
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<td>Dr. Fateh M. Marri, (PC-PCMU-WSIP, P&amp;D GoS)</td>
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</tr>
</tbody>
</table>
Irrigation Management Strategy for Irrigated Agriculture of Sindh Province (Pakistan)
Project Coordination & Monitoring Unit
Sindh Water Sector Improvement Project
Planning & Development Department
Government of Sindh

Contents

<table>
<thead>
<tr>
<th>S#</th>
<th>Main-Topics</th>
<th>Sub-Topics</th>
<th>Paragraphs</th>
<th>P #</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Executive Summary</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Strategic Initiative</td>
<td>- Set Water Resources Management in Place</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Strategic Direction</td>
<td>- Manage Vital Irrigation Assets/ Protecting Resource Base (Floods &amp; Droughts)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Strategic Direction</td>
<td>- Institutional Right Setting</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Strategic Direction</td>
<td>- Get the Financing System Right</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Strategic Activity</td>
<td>- Enhance Human Resource Capacity</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Strategic Activity</td>
<td>- Have Management Based on Information/ Building Knowledge Base</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Strategic Direction</td>
<td>- Develop Water Resources outside IBIS</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Strategic Direction</td>
<td>- Vitalize Agriculture &amp; Increase Agriculture Productivity</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Consolidation with ongoing projects and proposed future interventions</td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Acknowledgments</td>
<td></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Introduction</td>
<td></td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.1 Purpose of Study</td>
<td></td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.2 Context &amp; Background</td>
<td></td>
<td>9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.3 Structure of Report</td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Setting &amp; Baseline</td>
<td></td>
<td>11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.1 Economic Development Goals</td>
<td></td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.2 Irrigation System Network</td>
<td></td>
<td>14</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.3 Water Resources Assessment</td>
<td></td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.3.1 Canal Water</td>
<td></td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.3.2 Ground Water</td>
<td></td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.3.3 Irrigation Water Demand &amp; Use</td>
<td></td>
<td>17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.4 Institutions for Irrigation Water Management</td>
<td></td>
<td>21</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.5 Financing of Irrigation Sector</td>
<td></td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Issues &amp; Opportunities</td>
<td></td>
<td>27</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.1 Water Management</td>
<td></td>
<td>28</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.1.1 Challenges</td>
<td></td>
<td>28</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.1.2 Assessment</td>
<td></td>
<td>28</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.1.3 Improvement Opportunities</td>
<td></td>
<td>28</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.2 Multi-Functional Use</td>
<td></td>
<td>29</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.2.1 Challenges</td>
<td></td>
<td>29</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.2.2 Assessment</td>
<td></td>
<td>29</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.2.3 Improvement Opportunities</td>
<td></td>
<td>29</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.3 Institutional Framework</td>
<td></td>
<td>29</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.3.1 Challenges</td>
<td></td>
<td>29</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.3.2 Assessment</td>
<td></td>
<td>30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.3.3 Improvement Opportunities</td>
<td></td>
<td>33</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.4 Infrastructure Platform</td>
<td></td>
<td>33</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.4.1 Challenges</td>
<td></td>
<td>33</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.4.2 Assessment</td>
<td></td>
<td>34</td>
<td></td>
</tr>
</tbody>
</table>
Irrigation Management Strategy for Irrigated Agriculture of Sindh Province (Pakistan)

Project Coordination & Monitoring Unit
Sindh Water Sector Improvement Project
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Government of Sindh

<table>
<thead>
<tr>
<th>S#</th>
<th>Main-Topics</th>
<th>Sub-Topics</th>
<th>Paragraphs</th>
<th>P #</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.3</td>
<td>Improvement Opportunities</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td>Drainage of Agriculture Lands</td>
<td>36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5.1</td>
<td>Challenges</td>
<td>36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5.2</td>
<td>Assessment</td>
<td>37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5.3</td>
<td>Improvement Opportunities</td>
<td>39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.6</td>
<td>Protecting the Resource Base – Floods &amp; Droughts</td>
<td>42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.6.1</td>
<td>Challenges</td>
<td>42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.6.2</td>
<td>Assessment</td>
<td>42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.6.3</td>
<td>Improvement Opportunities</td>
<td>43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.7</td>
<td>Improving Agriculture Productivity</td>
<td>45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.7.1</td>
<td>Challenges</td>
<td>45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.7.2</td>
<td>Assessment</td>
<td>45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.7.3</td>
<td>Improvement Opportunities</td>
<td>45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.8</td>
<td>Building Knowledge Base &amp; Improving Human Resources Capabilities</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.8.1</td>
<td>Challenges</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.8.2</td>
<td>Assessment</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.8.3</td>
<td>Improvement Directions</td>
<td>47</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4 The Irrigation Management Strategy for Irrigated Agriculture of Sindh (Pakistan) 48

4.1 Reference Framework 48
4.2 Strategic Initiative, Activities & Directions 48
4.2.1 Strategic Initiative – 1 Set Water Resources Management in Place 49
4.2.2 Strategic Direction – 2 Manage the Vital Assets/ Protecting Resource Base 50
4.2.3 Strategic Direction – 3 Reform Institutional Framework 51
4.2.4 Strategic Direction – 4 Get the Financing System Right 53
4.2.5 Strategic Activity – 5 Enhance Human Resources Capacity 55
4.2.6 Strategic Activity – 6 Have Management Based on Information 56
4.2.7 Strategic Direction - 7 Develop New Irrigation Infrastructure in Areas outside 57
4.2.8 Strategic Direction - 8 Vitalize Agriculture and Improve productivity 58
4.3 Strategy implementation 60
4.3.1 Transparent Operations 60
4.3.2 (a) Financing 60
4.3.2 (b) Water Pricing 60
4.3.3 Performance Monitoring of Strategy 61

5 Sequencing of Priorities & Timelines 62

6 Conclusion 63

6.1 Way Forward 64

7 References 65

8 Appendixes/ Annexures 66
Figures List

<table>
<thead>
<tr>
<th>Figure-#</th>
<th>Title</th>
<th>Page-#</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Figure-1</td>
<td>IWRM Approach</td>
<td>8</td>
</tr>
<tr>
<td>- Figure-2</td>
<td>Irrigation Canal Network in Sindh</td>
<td>14</td>
</tr>
<tr>
<td>- Figure-3</td>
<td>Lower Indus Ground Water Quality Map, October 2010</td>
<td>16</td>
</tr>
<tr>
<td>- Figure-4</td>
<td>Growth of Public &amp; Private Tubewells in Sindh</td>
<td>17</td>
</tr>
<tr>
<td>- Figure-5</td>
<td>Design Allocations and Actual withdrawals of Sukkur Barrage Main Canals</td>
<td>18</td>
</tr>
<tr>
<td>- Figure-6</td>
<td>Actual Canal Diversions compared to Crop Water Requirements in Sindh &amp; Punjab</td>
<td>18</td>
</tr>
<tr>
<td>- Figure-7</td>
<td>Contrast of Canal &amp; Ground Water Use in Punjab &amp; Sindh</td>
<td>19</td>
</tr>
<tr>
<td>- Figure-8</td>
<td>IRSA's De Facto Rule for Water Allocation (FoDP, 2012)</td>
<td>32</td>
</tr>
<tr>
<td>- Figure-9</td>
<td>Water storage in various river basins (days of average flow they can hold)</td>
<td>34</td>
</tr>
<tr>
<td>- Figure-10</td>
<td>Irrigation Service Fees as a Function of Service Quality</td>
<td>61</td>
</tr>
</tbody>
</table>

Tables List

<table>
<thead>
<tr>
<th>Table-#</th>
<th>Title</th>
<th>Page-#</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Table-1</td>
<td>Consolidation with ongoing projects and proposed future interventions</td>
<td>5</td>
</tr>
<tr>
<td>- Table-2</td>
<td>Crop Yields</td>
<td>12</td>
</tr>
<tr>
<td>- Table-3</td>
<td>No of FOs and election status</td>
<td>24</td>
</tr>
<tr>
<td>- Table-4</td>
<td>Flow Distribution among Provinces (%)</td>
<td>32</td>
</tr>
<tr>
<td>- Table-5</td>
<td>Level of TDS of the Ground Water in Left Bank Areas</td>
<td>36</td>
</tr>
<tr>
<td>- Table-6</td>
<td>Indigenous tree/shrub species for plantation in areas affected by desertification in monsoon</td>
<td>41</td>
</tr>
<tr>
<td>- Table-7</td>
<td>Yield Gap for Major Crops (tons/ha)</td>
<td>46</td>
</tr>
<tr>
<td>- Table-8</td>
<td>Water Availability for Karachi</td>
<td>54</td>
</tr>
<tr>
<td>- Table-9</td>
<td>Current Water Rate Statistics of Karachi &amp; Different Cities in Sindh</td>
<td>55</td>
</tr>
<tr>
<td>- Table-10</td>
<td>Sequencing Priorities and Time Lines of Strategy</td>
<td>62</td>
</tr>
</tbody>
</table>

Boxes List

<table>
<thead>
<tr>
<th>Box-#</th>
<th>Title</th>
<th>Page-#</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Box-1</td>
<td>Quote for Potential of Agriculture in this Region</td>
<td>4</td>
</tr>
<tr>
<td>- Box-2</td>
<td>System of Rice Intensification</td>
<td>20</td>
</tr>
<tr>
<td>- Box-3</td>
<td>Irrigation Reforms Conceptual Model</td>
<td>22</td>
</tr>
<tr>
<td>- Box-4</td>
<td>Institutional Arrangement before Reforms</td>
<td>23</td>
</tr>
<tr>
<td>- Box-5</td>
<td>Institutional Arrangement after SIDA Act 1999</td>
<td>23</td>
</tr>
<tr>
<td>- Box-6</td>
<td>Institutional Arrangement after SWMO 2002</td>
<td>24</td>
</tr>
<tr>
<td>- Box-7</td>
<td>Summary of Priority Issues</td>
<td>27</td>
</tr>
<tr>
<td>- Box-8</td>
<td>Quote about Democracy</td>
<td>31</td>
</tr>
<tr>
<td>- Box-9</td>
<td>Rain Flood 2011 Scenario by Master Plan Consultants</td>
<td>37</td>
</tr>
<tr>
<td>- Box-10</td>
<td>Performance of available drainage facilities in left bank during 2011 Rain Flood Event</td>
<td>43</td>
</tr>
<tr>
<td>- Box-11</td>
<td>Badin District Crop wise cultivated area (1991-2010)</td>
<td>46</td>
</tr>
<tr>
<td>- Box-12</td>
<td>Thatta District Crop wise cultivated area (1991-2010)</td>
<td>46</td>
</tr>
<tr>
<td>- Box-13</td>
<td>Master Plan Phase-III Study on Sea Intrusion and Its Remedies through Ghyben Herzberg Theory</td>
<td>51</td>
</tr>
<tr>
<td>- Box-14</td>
<td>Water Conservancy Districts in Western United States</td>
<td>53</td>
</tr>
</tbody>
</table>
Executive Summary

This strategy concerns the future of Irrigated Agriculture in Sindh and the services that the irrigation sector will provide in the next 15 years. It is believed that the agriculture future of Sindh is bright, if it can be built on three potentials: i) Sindh’s strategic location in one of the world’s most dynamic regions; ii) the unused potential to make most of the water resources allocated to Sindh iii) and its young and abundant human resources.

The irrigation system is key to Sindh’s future. Ever since it was introduced it has sustained Sindh’s agricultural economy. Over the years the irrigation system has been stretched yet it has been miraculously able to cope with the increased demands and pressures. One single telling indicator here are the cropping intensities: these now stand at 150%: way beyond the 90% foreseen at the development of the system.

The irrigation system is also vital for the multiple services it provides. The canal system does not only provide water to the crops, but is also directly or indirectly the source of drinking water for humans and livestock. It provides scope for fishery and for navigation. At the same time it is used for effluent disposal – conflicting with other functions. The canal and drainage system infrastructure is important for transport and tree plantation and can play a role in housing and leisure. Being the defining element in the rural landscape in Sindh, the management of the irrigation and drainage systems goes beyond agriculture but touches upon all economic and social functions.

The high stress placed on the irrigation system has also come at a price. There is a less rigor in maintaining the irrigation assets; there is more encroachment and interference and there is uncertain financing. This needs to be set right and the irrigation sector needs to be protected in order to fulfill its role in a more prosperous future.

Sindh’s Irrigation Management Strategy seeks to have land and water resources of the region managed in accordance with the requirements of the provincial and national legislation and international norms. It describes that, institutional strengthening and focused investments are needed to improve water management and enhance the different functions served by the irrigation system, while considering its long-term sustainability. The productive use of irrigation water requires well-secured infrastructure and well developed human resources in the form of knowledge and institutions. Changes in water resources management, a selective overhaul of infrastructure, and bolstered capacity are necessary.

The Irrigation Strategy consists of a number of strategic initiatives for achieving the development goals related to irrigated agriculture. These initiatives are to be taken forward through broad, well-informed stakeholder participation and finalized in a collaborative way with all stakeholders. As mentioned, the irrigation system is far more intensely used that it was ever meant for yet it has been able to deliver. There are now far higher crop intensities; many canals carry more water than their design capacity and there is intense use of the irrigation and drainage network for other functions. Moreover, there is an almost complete conversion of the riverine flood plains to farmland. Add to this the challenge of climate change: the frequent flood events of the last five years and the seawater encroachment in the coastal areas. The image is of a system that is literally ‘bursting at the seams’.
Strategic Initiatives, Directions and Activities
The strategy for Irrigated Agriculture in Sindh would include following initiatives and investment directions.

1. Set Water Resource Management in Place
2. Manage the Essential Irrigation Assets/ Protecting Resource Base
3. Institutional Right-Setting
4. Get the Financing System Right
5. Enhance Human Resource Capacity
6. Have Management Based on Information/ Building Knowledge Base
7. Develop Water Resources Outside IBIS
8. Vitalize Agriculture

Set Water Resource Management in Place: This would consist of better balanced supply of surface water, to promote the conjunctive use of groundwater and surface water where possible, given salinity levels, and free up water in the process multifunctional use. It would also entail controlling the now incessant pollution by discharge of untreated wastewater – enforcing treatment and promoting reuse of wastewater, the latter in some case being profitable in itself. Sindh Province has limited fresh ground water aquifers, which are also facing over exploitation. This is an open invitation for saline aquifers to permanently encroach this precious resource. Limited areas in Sindh (e.g. the Riverine Area upstream Dadu, South Rohri Canal Command and Northern Right Bank aligned with Indus) have the fresh groundwater to use, but for the large majority of agricultural lands, groundwater is not a viable option. The only feasible way forward for Sindh is to reform, rationalize and revitalize the canal irrigation system along with legislation for regulation of ground water use.

Manage the Vital Irrigation Assets/ Protecting Resource Base (Floods & Droughts): With the irrigation system stretched far beyond what it was originally designed and a large part of the vital infrastructure aged, an overhaul of the irrigation systems is due. This concerns a reconsideration of the current actual irrigation duties but also an assessment of priority improvements concerning infrastructure. The first step is a review of the main diversion works, an assessment of drainage priorities (after the water distribution system is set right), a detailed assessment and plan for coastal regions now under severe threat and the development of storage options at different levels in the irrigation system in Sindh. In Toto, we need to ensure that our Infrastructure is Climate Change Threat Resilient.

Institutional Right-Setting: The team’s understanding is that the institutions responsible for irrigation management are not functioning properly, and they lack coordination and integration. Especially disappointing is the inability of the Irrigation Department (ID), Sindh Irrigation & Drainage Authority (SIDA), Area Water Boards (AWB) and related farmers’ organizations (FOs) to deliver the expected benefits of improved management through user participation\(^1\). The ID and SIDA have not been able to work in an integrated way to improve system O&M and irrigation water delivery to farmers. This problem must be addressed urgently to check the rapid deterioration of water governance, poor condition of canal infrastructure and inability of small farmers to access their due share of canal water.

\(^1\) Farmer organizations (FO) and Water User Associations (WUA) were established under the 2002 Sindh Water Management Ordinance.
The irrigation reforms, initiated in 1997 are stalled and still confined to a small part of the huge irrigation system of Sindh. An assessment of valuable elements of the reforms, for instance financial autonomy and active user engagement, is to be done to see what can be mainstreamed. There is a case for appreciating the importance of the essential irrigation system and get the support of judiciary and local government to protect the system from interference and encroachment. There is also a need to right-position. Some human resources are overstretched, other not much used. This needs to be corrected. The same applies to the spending of financial resources: there are some unnecessary burdens, such as drainage wells operations, even where they no longer function. This needs to be set right.

**Get the Financing System Right:** This is a tall order, yet up to 1973/1974 the abiana covered all costs and more. The current situation is far from that. The abiana system needs to be vastly simplified based on land and irrigation duties. The rates need to gradually rise. Other sources of income from the irrigation sector – from tourism, water front real estate, tree planting on canal banks, fishery rights, realistic water pricing of deliveries to urban water supply all need to come in place to create a healthy and vibrant system. Water Pricing is serious issue, as it is always confused on social values as basic human right. In fact, it is cost of delivering basic life necessity. Nowadays, Agriculture, Municipal, Industrial or Environmental water deliveries are facing serious conveyance efficiency issues due to lack of O&M investments. The cost of one gallon supplied in bulk to municipal users is 0.17 PKR, in comparison same volume of bottled water is sold in market from 100 – 250 PKR.

**Enhance Human Resource Capacity:** There is a high degree of professionalism in the irrigation sector: the irrigation system management is very much an art. At present much learning is on-the-job and from peer-to-peer. Whilst there is nothing wrong in this, to equip Sindh’s irrigation cadre for the challenges up to 2030 and live up to the promises. The Irrigation Academy at provincial and national levels should be revived and become the center of learning and innovation and sharing excellence.

**Have Management Based on Information / Building Knowledge Base:** Closely related to all above, irrigation management cannot fly blind. The collection of vital management data should be secured and disseminated, that will be reliable basis for day-to-day decisions. The data fields include flow measurements, cultivation figures, flood forecasting/ early warning systems, rain fall estimation, irrigation deliveries at farm gate, crop outputs, groundwater levels & quality.

**Develop Water Resources Outside IBIS:** The team has identified three priority areas for increasing agricultural productivity. The first action area: i) improved on-farm water management, which is a proven technical and political success which can continue to give large returns. The second is: ii) the construction and modernized operation of small dams, and iii) is improved spate irrigation in areas outside the Indus Basin Irrigation System (IBIS). The last two interventions will increase ground water recharge and its use in Arid Zones. These all interventions also have broad political support and can result in large increases in agricultural production. WAPDA and Irrigation Department, GoSindh have constructed small dams and water retention weirs outside IBIS e.g. Darwat Dam, Winder Dam, and nineteen small dams/ retention weirs in Tharparkar, Dadu and Jamshoro regions. However, there is no corresponding water management advisory service to help farmers put the stored water to beneficial use. The OFWM advisory service should be made an integral part of the small dams’ development.
Vitalize Agriculture & Improve Productivity: The most important measure – the productivity of agriculture, measured in terms of total production or productivity per unit of water and land – remains low by global and even regional standards (USAID, 2009). Today the situation is a difficult downward cycle: the quality of service is poor; many areas have too much water and suffer from waterlogging and salinity, while other areas have too little water; and “investments” are not for constructing new capability but trying to make up for non-existent maintenance. Sindh Agriculture system needs strong interventions, for proper crop care techniques and marketing system. The saline zones may be encouraged to adopt Bio-Saline agriculture techniques. Farmer’s access to information through modern day media sources may be enhanced.

Box-1: Quote for potential of Irrigated Agriculture in this region²

Consolidation with ongoing projects and proposed future interventions Table-1:

<table>
<thead>
<tr>
<th>Strategic Priorities</th>
<th>Ongoing Projects</th>
<th>Proposed Future Interventions</th>
</tr>
</thead>
</table>
| **Set water resource management in place**  | • Sindh Irrigated Agriculture Productivity Enhancement Project  
                                                • Training and Capacity Building of Farmers for better water management under Sindh Water Sector Improvement Project | • Introduction of Water Accounting Mechanism at Farm Gate Level, integrated with Water Courses Improvement Projects.  
                                                • Ground Water Management Project                                                                      |
| **Manage the vital assets**                 | • Sindh Barrages Improvement Project for Guddu Barrage  
                                                • Preparation of Sukkur Barrage Rehabilitation and Modernization Project.  
                                                • Rehabilitation of Nara, Ghotki and Left Bank Canals under SWSIP.  
                                                • Climate Resilient Water Management Project.  
                                                • Master Plan for Left Bank of River Indus, Delta & Coastal Zone                                           | • Structural Audit, Diagnosis of Irrigation Department Major Control Structures, Designed Capacities and Flow Requirements, Over Haul Projects.  
                                                • Execution of Master Plan Left Bank Feasibility Studies.  
                                                • Topographic Surveys for Indus River Basin Flood Management in Sindh.                                   |
| **Institutional right-setting**             | • Irrigation Reforms under SWSIP, SIDA, AWBs & Farmer Organization.                                          | • Further enhancement of SIDA jurisdiction, notification of Area Water Boards on further Canals. Formation of Farmer Organizations.                      |
| **Get the financing system right**         | • Financial Autonomy of Irrigation Management System, sustainable O&M through Irrigation Reforms under SWSIP-SIDA | • Further Studies to Analyse present day, O&M Cost and Expenditures.  
                                                • Introduction of SWMO 2002 on remaining main canals of Sindh                                           |
| **Enhance human resources capacity**        | • Capacity Building of GoSindh Irrigation, SIDA, Finance, P&D & Agriculture Department Staff through National & International Trainings under SWSIP and Sindh Barrages Rehabilitation Project.  
                                                • Establishment of Centre of Excellence in Water Studies at Mehran University of Engineering & Technology | • New cadres of irrigation professionals and new standards of operation.  
                                                • Revival of Irrigation Academy and Research Centres for Water Management and monitoring                   |
| **Have management based on information**    | • Installation of latest flow measurement gadgets at Nara Canal Area Water Board connected with MIS.  
                                                • Installation of latest flow measurement gadgets at Guddu Barrage.  
                                                • Boats and Bathymetric Survey Equipments for river bed surveys in running water.  
                                                • Use of GIS for digitization of Irrigation network and mapping of cultivated area under SWSIP.         | • Installation of Flow Measurement devices on all Main and Branch Canals of Sindh connected with centralized MIS data base.  
                                                • Digitization of Command & Crop wise cultivated areas through GIS updated yearly.  
                                                • Ground Water monitoring, digitized mapping of quality, quantity and depths.                            |
| **Develop water resources outside IBIS**    | • Sindh Small Dams Project                                                                                   | • Installations of High Efficiency Irrigation Systems on small dams and retention weirs built in Thar and Kohistan Area.  
                                                • Diversion of Flood water for storage in lakes in Thar near Sanghar and Badin Areas                      |
| **Vitalize agriculture**                    | • Sindh Agricultural Growth Project                                                                          | • Scale up bio-saline agriculture.                                                                 |
                                                |                                                                                                              | • Encourage investment in storage and agricultural innovation and services.                               |
Acknowledgements

The Project Coordination & Monitoring Unit (PCMU) for Sindh Water Sector Improvement Project (WSIP) under Planning & Development Department (P&D), GoSindh served as host for this assignment. We are thankful to Mr. Waseem Ahmed, Additional Chief Secretary (Dev.) for his patronage and overall support of this activity.

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We believe this report provides a good basis for the Irrigation Management Strategy, and we trust the Government of Sindh will find it useful for future planning and benefit of people of Sindh.

Best Wishes:

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1. Introduction

1.1 Purpose of the Study and Report

This report is an assessment and diagnosis of irrigation institutions and infrastructure in Sindh Province of Pakistan, with a view to come to a strategy for better managing water use in irrigation sector. The strategy would promote efforts to obtain an efficient and equitable use of irrigation water for social and economic development on a sustainable basis. The findings and recommendations of this report were arrived at by following the IWRM (integrated water resources management) approach involving the steps of:

- Setting a Water Resources Vision - Policy,
- Conducting Situation Analysis,
- Identifying Priority Issues,
- Formulating a Draft Strategy to address Priority Issues, and
- Implementing, Monitoring and Evaluating Performance (United Nations, 2008; Fig. 1).

This diagnosis results from stock taking of documentation and interviews and workshop sessions at the major barrages. This permitted a situation analysis (section 2) to identify issues and opportunities (section 3), and formulate a draft strategy for irrigation management in Sindh. This draft strategy is placed in section 4. The draft strategy is meant for debate and acceptance by the main stakeholders in the irrigation sector in Sindh.

Figure 1: Integrated water resources management approach

1.2 Context and Background

The Government of Sindh is reviewing its water management policies and infrastructure programs to ensure food, energy, and environmental security. Irrigation management strategy is needed for addressing issues in a coordinated way across levels of government and other stakeholders. Since 1997, the World Bank has assisted Sindh Government in its efforts to improve its water sector through Participatory Irrigation Management Approach (PIM), and a comprehensive strategy must be in place to guide further development efforts and investment.

In 2003, the FAO Investment Centre undertook a comprehensive study of water resources in Sindh on behalf of the Sindh Government and the World Bank (FAO, 2003). This study analyzed issues and options for water resources management, in particular in the irrigation and drainage sub-sector. The study identified following areas in need of improvements.

- Irrigation System Operations and Maintenance,
- Quality of Water Delivery Service,
- On-farm Agricultural Productivity,
- Irrigation Network Assets management and,
- “Most importantly, Modernization in place of Rehabilitation of Irrigation and Drainage Infrastructure, as rehabilitation is found to perpetuate the vicious cycle of “build, neglect and rebuild” (FAO, 2003).

The findings of the FAO study were utilized to prepare the Sindh Water Sector Improvement Project (WSIP), which is currently under implementation and has sponsored this strategy formulation effort. It is important to note that the irrigation sector still faces these issues. In 2003, after promulgation of the SWMO (Government of Sindh, 2002), there were high expectations that the newly formed Sindh Irrigation and Drainage Authority (SIDA) and farmers’ organizations will be able to resolve these issues. In 2011, a Water Task Force established by the Friends of Democratic Pakistan conducted a comprehensive analysis of Pakistan’s water sector and their report is available since 2012 (FoDP, 2012). The FoDP report has provided useful guidelines for this strategy formulation. The team also reviewed several other background reports related to national water resources policy and development programs, the 1991 Water Apportionment Accord, the 1997 Provincial Irrigation and Drainage Act, Master Plan for Left Bank of River Indus & Delta Coastal Zone, and the irrigation and drainage system management in Sindh.

Recently, the Government of Pakistan has framed Vision 2025: 2015-2025 with 11th Five Year Plan (2013-18) to guide national economic development. Water security is identified as part of one of the pillars. Specific targets are set: increase water storage capacity to 90 days, improve efficiency of usage in agriculture by 20%, and ensure access to clean drinking water for all Pakistanis; and reduce the food insecure population from 60% to 30%. With water being a provincial topic, this document sets out the basis for a Sindh Irrigation Strategy that would serve irrigated agriculture and other functions.
1.3 Structure of Report

The findings of this study are presented in four chapters. Chapters 1 and 2 are mostly introductory chapters providing background information on irrigation sector in Sindh. Chapter 2 includes an assessment of available water resources in Sindh and their utilization in various sectors of the economy. It also provides background information on how water resources are managed including the vital physical infrastructure and related organizations, legal framework and financing. Chapter 3 provides a comprehensive analysis of issues/challenges, team’s assessment of the main causes, and opportunities for addressing the issues. After understanding issues and opportunities for solutions, we formulate our approach and steps, or strategy, for solving these issues in chapter 4. Towards the end, we outline the strategic initiatives that the government can implement for addressing the identified issues.
2. Setting & Baseline

Sindh is located in the south of Pakistan where the Indus River discharges into the Arabian Sea. It is the second largest province of Pakistan, with a population of about 44 million (about 23% of total country population). Population growth stands at 2.8%. This places an increasing pressure on resources such as water to provide employment opportunities and contribute to economic growth. Rural Sindh is moreover a hotbed of poverty with 53% of the population classified below the poverty line (compared to 33% of Pakistan and 37% for entire Sindh respectively). Last but not the least, efforts to strengthen the irrigation services has to address this important challenge of speedy urbanization and its water requirements.

This province is a hot and dry region, before the advent of canal irrigation in 1930s was essentially a desert with freely meandering river course. The annual average rainfall of less than 200 mm was insufficient for crop production. The Indus River, fed by the Himalayan snowmelt, is the primary source of water for meeting all societal needs. Irrigated agriculture is by far the largest water user, accounting for about 90% of the river diversions. The vast Indus Plains contain fertile alluvial soils that can support intensive agriculture but the available water supplies are insufficient for all to practice year round cropping. The original design cropping intensity for the canal irrigation system was about 35% in the hot summer season and about 55% for the cool winter season. The present day cropping intensities are reportedly much higher – about 70% for each season or an annual cropping intensity close to 150%. There are two growing seasons: the summer Kharif season (April to September) and the winter Rabi season (October to March).

There are concerns that climate change will result in the disappearance of much of the glaciers, which will lead to far more irregular Indus flows. There are already several manifestation of a changed natural environments: the three floods that occurred in the last five years and the dramatic changes in the coastal areas where sea intrusion has increased after dramatic changes in coastal morphology.

Irrigated agriculture is by far the largest water user in Sindh, accounting for about 90% of the river diversions. The vast Indus Plains contain fertile alluvial soils that can support intensive agriculture but the available water supplies are insufficient for all to practice year round cropping. The original design cropping intensity for the canal irrigation system was typically 35% in the Kharif summer season and 55% for the Rabi winter season (with variations for non-perennial canals). Over the decades the system has been put on ever-larger stress and has been able to respond to the ever-larger demands. The present day cropping intensities are much higher – close to 70% for each season or an annual cropping intensity close to 150%. Canals also carry far larger discharges than what they were designed for. The Comparative Analysis of Canals Original Design Discharges with Actual Flows show that some sections receive disproportional volumes of water due to the siltation of certain canals but more importantly because of increases in diversion in upper reaches as a result of widened upstream off-takes or a proliferation of direct outlets.
2.1 Economic Development Goals

Agriculture is the mainstay of Sindh economy. It accounts for substantial employment in rural areas, thus contributing to rural livelihoods while ensuring household and national food security. In labor tenancy and labor contracts are common, often loaded against the workers. More opportunities for small farm operators may spread the productive opportunities and contribute to more high value agriculture.

Most crop production takes place on irrigated lands in the plains area of the Indus River basin. Yields of most crops are low by international standards, both in terms of land and water productivity (FoDP, 2012). Typical yields are given in Table-2:

<table>
<thead>
<tr>
<th>Crops</th>
<th>Yields (kg/Hectares)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>KHARIF</strong></td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>2787</td>
</tr>
<tr>
<td>Cotton (Lint.)</td>
<td>622</td>
</tr>
<tr>
<td>Pulses</td>
<td>455</td>
</tr>
<tr>
<td>Fodder</td>
<td>25000</td>
</tr>
<tr>
<td>Sorghum</td>
<td>578</td>
</tr>
<tr>
<td><strong>RABI</strong></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>2343</td>
</tr>
<tr>
<td>Pulses</td>
<td>666</td>
</tr>
<tr>
<td>Oilseeds</td>
<td>3053</td>
</tr>
<tr>
<td>Fodder</td>
<td>30780</td>
</tr>
<tr>
<td><strong>PERENNIAL</strong></td>
<td></td>
</tr>
<tr>
<td>Sugarcane</td>
<td>58500</td>
</tr>
<tr>
<td>Orchards</td>
<td>5800</td>
</tr>
</tbody>
</table>

Performance of agriculture in Sindh is directly linked with the supply of irrigation water from the Indus River. Wheat, rice, sugarcane and cotton are the major field crops that constitute 68% of the total cropped area, while mango, banana and chilies are the major horticultural crops. Rice and sugarcane, both very high water consuming crops, have replaced cotton as the major summer crop. Contribution of groundwater in meeting crop water requirement is very small. – Making it more difficult to provide water on demand.
Availability of quality seed of desired crop varieties is a problem of major concern for Sindh agriculture. Supply of substandard and adulterated pesticides and fertilizers affects crop yields and the cost of production. There is increasing degradation of the land and water resource base, especially through water logging and salinization, and the current farming practices do not adequately address the issue of sustainability of crop production systems. This is besides the high cost of inputs and non-secure market prices as the main hurdles in the development of agriculture. Though there are exceptions, there is relatively less innovation and use of new techniques in farming in Sindh and bulk crops still predominate.

A majority of rural households do not own agricultural or homestead land. Of those who do own land in rural areas, fewer than 20% are large landlords but this group owns over 60% of the private farms. The existing sharecropping/tenancy system, concentrated in the canal-irrigated areas, is historically deep-rooted. It perpetuates the deeply entrenched poverty of tenants and agricultural labor through unbalanced revenue and cost sharing arrangements and a complex system of dependencies. Recognizing the need for more equitable distribution of agricultural land and security of tenancy, the Government of Pakistan has attempted land reforms in the past, but without much success in Sindh.

Recently, the Government of Pakistan has framed Vision 2025: 2015-2025 with 11th Five Year Plan (2013-18) to guide national economic development. The Vision 2025 would address country’s development through following seven pillars:

- People First: Developing Social and Human Capital and Empowering Women,
- Growth: Sustained, Indigenous, and Inclusive Growth
- Governance: Democratic, Institutional Reform and Modernization of the Public Sector
- Security: Energy, Water, and Food Security
- Entrepreneurship: Private Sector and Entrepreneurship-led Growth
- Knowledge Economy: Developing a Competitive Knowledge Economy through Value Addition
- Connectivity: Modernizing Transport Infrastructure and Regional Connectivity.

The 4th pillar of Vision 2025 (water and food Security), sets following objectives for the water and food sectors:

- Water: Increase Water Storage Capacity to 90 days, improve efficiency of usage in agriculture by 20%, and ensure access to clean drinking water for all Pakistanis;
- Food: Reduce Food Insecure Population from 60% to 30%.

The three concerns related to water sector – increasing storage capacity on national basis, improving water use efficiency in agriculture and improving access to clean drinking water – are very real for Pakistan and for Sindh.
2.2 Irrigation System Network

Irrigation is critical for agriculture in Sindh, as the contribution of rain towards crop water requirements is negligible. Canal water diverted from the Indus is the primary source of irrigation water, followed by groundwater pumping. River water is diverted at three barrages – Guddu (commissioned 1962), Sukkur (1932) and Kotri (1955). It is then conveyed in 14 main canals to service a total design area of about 5.1 million hectares (mha). The actual irrigated area varies depending on the amount of available water, with an average of 3.8 mha. The diversion capacity of the canals off-taking from Guddu Barrage is 45,000 ft³/s; from Sukkur Barrage, it is 58,000 ft³/s; and from Kotri Barrage, it is 35,000 ft³/s. The total design diversion is therefore 138,000 ft³/s. But, the actual diversions and flows in the canals are reportedly at least 30-40% higher, which has become necessary because of the increased cropping intensity and the cultivation of high water-consuming crops such as rice and sugarcane. Also, the canal conveyance losses have increased in the earth canals.

Almost 50% of the design service area, amounting to 2.4 mha, does not have land drainage facilities. This is a serious constraint to crop production since much of the agricultural land is flat with low natural drainage. The flat topography combined with high water losses at farm and excessive canal seepage have resulted in extreme water logging and salinity. Close to 30% of irrigated land is now salt affected, and salinity poses a serious threat to the sustainability of irrigated agriculture in Sindh (FAO, 2003; Habib, 2011). Controlling water logging and salinity will substantially increase crop yields and crop production and as such should receive investment priority in the irrigation sector.

Prior to all, the problems of high irrigation duties and unscheduled supplies should be resolved, as it makes no sense to invest in drainage if its main purpose is to remove excess water from high irrigation duties.
2.3 Water Resources Assessment

2.3.1 Canal water

In 1991, the Federal Government and the Provinces agreed on an accord on the apportionment of surface water among the provinces. Under the Water Apportionment Accord, Sindh’s annual share is 60.17 \* 10^9 m³ (48.76 MAF) – 41.88 \* 10^9 m³ (33.94 MAF) in summer and 18.29 \* 10^9 m³ (14.82 MAF) in winter. The actual supplies to the province vary, depending on water availability in the Indus System. The inflows at the Guddu Barrage, the first gauging point in the province, include the share of Sindh released as per the Water Accord and the surplus unutilized water in the System. Since 1991, the inflows at Guddu have varied between a high of 131 MAF and a low of 43.5 MAF with an average of 88 MAF\(^3\). On an average, 72.5 MAF flowed in Kharif and 15.5 MAF in Rabi. During the same period, the average outflow to the sea below Kotri was of the order of 36 MAF. The outflow varied over a wide range between a low of 0.7 MAF in 2000-2001 and a high outflow of 91 MAF in 1994-95. Allowing a proper amount of discharge to the seas, we still have a large amount of water that can be conserved, by developing the necessary storage capability.

The irrigation canal system is not only important for agricultural water supply. It serves many functions and is the defining element of the landscape in most of Sindh. It provides waterfronts, recreational areas, transport on inspection roads and space for tree planting. Other important functions served by the irrigation canal are serving as the source for urban and rural water supply, for livestock water and fishery. It serves additional functions such as sand mining, navigation and many others.

These multiple functions are generally not well managed. Most telling is the uncontrolled use of the irrigation network to discharge untreated wastewater. This can be seen from sugar mills that release their effluent on irrigation canals and drains, causing the water to become toxic and anaerobic with grave danger for downstream use. Equally dangerous is the release of wastewater from industrial estates (SITE, I, Darya Khan Pumping Station), agricultural industries (poultry farms, dall mills) and urban areas into the canal systems. This may be illustrated by the Fulleli Canal, which receives 102 cusecs of untreated waste water – containing biological waste, suspended solids, heavy metals, waste of garment industry, pharmaceutical plants and metallurgical industries from more than 40 waste inlets in and around Hyderabad. The Fulleli Canal is also the prime source of domestic water for more than 1,500,000 people living downstream. The impacts of water contamination are briefly discussed in Para 3.4(a).

2.3.2 Groundwater

Estimated ground water resources for the Sindh Province vary between 13 to 16 MAF with an estimates safe yield between 4.4 to 8.0 MAF. The shortage and unreliability of canal irrigation water in Sindh has increased the importance of developing groundwater wherever fresh water or even saline water of marginal quality is available. However, effective development and use of groundwater in Sindh – with the exception of a number of intensely developed areas – has been much lower than

\(^{*}\)The unit of volume 1 million acre-feet = 1.23 billion cubic meters
Punjab. The invisibility of groundwater in Sindh is exacerbated by the fact that since 2008, monitoring groundwater has been suspended in spite of persistent water logging.

Reliable data on extent of groundwater use in the province are not available. Fresh groundwater is found mostly in a strip parallel to the left bank of Indus River and in few other pockets (Figure 3). The estimate is that in 46% of the land in Sindh useable (< 1000 mg/l TDS) groundwater is available at shallow depth (<15 meters). This area reduces if one looks at groundwater resources at larger depth (45-50 meters), which usually occurs at 20-25 meters depths: in that case only 30% is usable. There are near to 100,000 tube wells in Sindh. Of these about 4,100 are public tube wells (many dysfunctional or under de facto farmers management) and 96,000 are in the private sector. The present groundwater pumping is estimated to be about 4.2 MAF on an annual basis. Some of the public tube wells were installed for drainage and pump saline water. The private tube wells pump fresh groundwater or marginal quality groundwater, which is sometimes used after mixing with canal water. Recent reports are that more than 85% of the public tube wells are non-functional due to lack of proper maintenance, though more than 35% of the IPD O&M costs are allocated for the tube well operations. There is still unused potential to use groundwater in Sindh, in particular in areas with fresh groundwater that are now provided with very high surface water deliveries, as for instance in command Guddu Feeder. If these surface deliveries are rationalized, more groundwater would be pumped – allowing more precise and productive farming, besides water-saving and reduction in area under water logging. In other areas of the province the development of groundwater should be guided, particularly those underlain with ground water of poor quality at larger depth, as indiscriminate pumping can result in up-coning of the saline groundwater. The Issue of Ground Water Regulation in Punjab and Sindh is still unaddressed. There is dire need of proper laws and control. The recent river floods of 2013 and 2014 have indicated major draw down in flood water. There is continuous uncertainty in floods. In case the over exploitation continues, the draw down may cause saline water accumulation in fresh water aquifers, which will permanently diminish this resource. The increase in public and private tube wells is presented figure-4:

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Number of tube wells in Sindh is barely 5% of the total number in Pakistan (close to one million). More than 80% of the tube wells are located in Punjab.
2.3.3 Irrigation water demand and use

The current population of Sindh is about 44 million. This is projected to increase to 54 million in 2025. The increased population growth and urbanization will require increased agricultural and food production and more job opportunities. It is estimated that by 2025 the irrigation water requirements for agriculture would increase by about 50% if the current irrigation practices continue (A. Azad, 2003). Total river water diversions in 2012 were estimated at 60 bm³ (48.78 MAF), of which about 54 bm³ (43.9 MAF) or about 90% was for agricultural purposes (FoDP, 2012). This means that an additional 30.0 MAF will be required for irrigated agriculture in 2025 to maintain the current balance between supply and demand of agriculture products (A. Azad, 2003). The groundwater abstraction was roughly estimated at 4-6 bm³/year (5 MAF/year). The additional water required under this projection is simply not there and a business-as-usual approach for Sindh will not do. More efficient use of existing resources is imperative hence.

Actual main canal abstractions are generally much higher than their design allocations, especially in the canals that take off from the two upstream barrages. The data provided in Figure-5,

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6 This is a very large amount of water for servicing a total command area of 5.1 mha (actual cropped area is reported to be close to 3.2 mha). In comparison, Egypt’s annual allocation on the Nile River is almost the same (55 bm³), but the irrigated area is about 8.5 mha. And, the crop yields in Egypt are double than in Sindh.
clearly support these statements. The two large canals at the Sukkur Barrage, Nara and Rohri Canals, routinely withdraw higher water amounts than their design allocations. The Nara Canal, with a design allocation of 4.95 MAF withdraws 6-8 MAF, and the Rohri Canal withdraws 6-9 MAF compared to its allocation of 3.94 MAF. Even during the drought period of 1999-2003, the canals withdrew slightly more than their design allocation.

**Figure-5. Design allocations and actual withdrawals of Sukkur Barrage main canals.**

It is common practice for engineers to be compelled to run main canals up to 40% higher discharge by influential large landowners, who plant more and more rice and sugarcane crops and have developed fish farms. Further, in some areas farmers use the local practice of flooding the rice plots and maintaining water flow through the flooded basins, eventually wasting water to drains (*puncha* method).

**Figure 6: Actual canal diversions compared to crop water requirements in Sindh &Punjab**

Dr. Zaigham Habib (2011) researched the correlation between actual canal diversions and crop water requirements (Figure-6). Data in Fig. 6 show that in case of Punjab, diversions at the head of main canals are equal to the crop water requirements, while in Sindh and Baluchistan, canals diversions are 160% of the crop water requirements – indicated the large gains that Sindh can still make in water management and addressing future water demand.

As mentioned, another reason for the increased use of canal water is the lack of properly regulated groundwater development in Sindh, the obstruction in the path is constantly increasing menace of Water Logging and Salinity and absence of properly owned and operational drainage system. Today Sindh has to use extra irrigation supplies to leach down soil salinity and get reasonable crop outputs. In contrast, Punjab has been the scene of a virtual groundwater revolution as the majority of Pakistan’s million tube wells are located there. The tube wells have made up for the unreliability and shortfall in surface water supplies from the canal system and have supported cropping intensity exceeding 150%. The groundwater situation in Sindh starkly contrasts with that in Punjab as is clear in Figure-7. Whereas in Punjab groundwater is largely used in the canal commands, in Sindh this is not the case (see right side of the graph). This is caused by both the more widespread salinity of groundwater in Sindh but also importantly the high irrigation duties and additional diversion on top of these. These make it unattractive to pump groundwater and moreover give rise to widespread water logging, further reducing the incentive to pump and supplement surface water with groundwater.

**Figure-7. Contrast of Canal and groundwater use in Punjab and Sindh**

Running main canals at discharges higher than the design is very difficult and dangerous practice. To divert larger discharges into the canals, the engineers are operating the barrages at upstream pool levels that are dangerously high – more than 5 feet in excess of design at the Guddu Barrage. The high pond level means more water pressure on the control gates, more seepage loss
and very high river embankments. The canals are mostly earthen with water levels more than 20 feet higher than the surrounding land. Running them at flow discharge in excess of 16,000 ft$^3$/s compared to a design discharge of 10,000 ft$^3$/s is dangerous. The canal breaches are frequent and result in large loss of life and property. The excess flow will erode the canal section, which becomes larger and larger with time and will need more flow to fill it to design water level. This practice of running canals at very high capacities needs to be carefully reviewed and possibly stopped. In addition to the security and equity considerations, good quality lands are being turned into waterlogged saline lands. There is relatively little effort in implementing water saving measures. The water management system with the high water logging entails enormous water losses. For Sindh province some 74-80% of the available groundwater recharge is lost in the form of non-beneficial evaporation. This loss could have been used for productive use (as potential recharge), results from canal losses and irrigation returns. It occurs over both the fresh groundwater zones and saline groundwater zones of the province, in the ratio of 25:75 by area (Water Watch and Osmani 2005). There is a need for a complete overhaul of the water management in the irrigation system of Sindh, starting with reassessing the irrigation duties for the different canal commands – this would improve productivity on existing land and free up water for other areas and uses. Another win-win is an improvement in field water agronomy: here there are considerable opportunities too. The Department of Agriculture staff can assist by informing farmers of more efficient ways to cultivate rice. For example, the SRI method of cultivating rice gives high yield while consuming much less water than the wild flooding (refer Box-2).

The System of Rice Intensification (SRI – see http://sri.ciifad.cornell.edu/) is a farm-based approach that increases the value of a rice crop, in both absolute and productivity terms. Since being validated by ICRISAT, the system, which is not variety dependent and works as well with rain-fed rice as irrigated, is being actively promoted by the World Bank. The benefits claimed for SRI include:

- modest increases in yields/unit of area
- significant increases in yields/unit of water
- reduced canal size, and hence investment costs, storage and servitude requirements of new irrigation schemes
- reduced need for phased planting resulting from the need to rotate pre-saturation supplies, which in turn reduces pest damage
- SRI rice has been found to resist lodging, which is proving beneficial in typhoon prone areas.
- Reduction in seeding requirements, thereby increasing the profitability of higher yielding, pest resistant hybrids.
- quality of milled grain is reportedly improved, thus increasing its market value and hence the productivity of water and labor;
- In some cases (i.e. Cambodia, India and Nepal) shorter growing seasons have also been claimed, this too contributes to water savings and in some cases might increase profits by selling ahead of peak market supply.

The practices required to achieve these benefits are as follows. All are necessary to achieve the best results, although where it is not possible to do all of them a combination of some can produce benefits; but where irrigation is concerned, it must be precise. Thus:

- Germination on nutrient rich nurseries
- Early transplanting (9-12 days) with seedlings placed gently on the surface, reducing transplant shock
- Wide spacing (usually 25-30 cm)
- use of organic fertilizers that nourish not just the plant, but also increases microbial activity within the root zone, where microbes provide energy in a way that benefits the growing rice plants.
- regular weeding using implements that also aerate the root zone (which maintains healthy root zone fauna

Box 2: System of Rice Intensification (SRI):
2.4 **Institutions for Irrigation Water Management**

The existing Indus Basin Irrigation System (IBIS), developed since 1860, was legally protected by the Canal and Drainage Act, 1873. The irrigation canal network was planned and designed as a gravity flow principle of hydraulics, where water once diverted at the river will flow more or less automatically through the canal network, eventually arriving at the farm. The design duties or allowances of the canals vary from 2.5-3 cusecs /1000 acres in Punjab and to 8-10 cusecs /1000 acres in KPK province. Irrigation allowances in Sindh vary with some canals being in the same bracket as KPK. The command area of each tertiary outlet (watercourse command) receives water typically on a seven-day rotation. There are a number of areas (like upper Nara) where water is provided by pumping stations.

Within the watercourse command, each farmer has the right to divert all flow for a specified time period based on his/her landholding size (the water allocation and distribution system is called warabandi or fixing turns). The provincial Irrigation and Drainage Department (IPD) is legally responsible to provide authorized flows at different levels of the canal network, but the actual flows show large variation. The equitable distribution of available water against design duties of various canals is a key regulatory criterion. In practice, there is very little measurement of canal flow discharges and the amount of water deliveries at various points. There is moreover uncertainty as regards the entitlement for each water course: this is because the ‘design discharges’ have not been updated after the changed water regime following the larger river regulation that came with the construction of the Tarbella Dam and as shown above the actual canal intakes are in most cases considerably more. In addition there are several examples where command areas is enlisted less than one water course, but effectively better reached from another watercourse. Over the years there has been a dynamic moving around of watercourses and this has left also a degree of confusion and misalignment, often for poorer farmers (Indus Consortium 2014). The canal network is operated by monitoring water levels, and obtaining a specified water level at the downstream end of distributary canals is the key regulatory criterion.

Responsibility for the water sector in Pakistan is shared between federal and provincial bodies. The ID is the main provincial government organization with mandate to effectively manage the irrigation canal network, whereas the Department of Agriculture assists water users with agricultural production (Figure 6 shows organizational chart for the two organizations). Policies and planning are the responsibility of the provincial Department of Planning and Development and the Federal Ministry of Water and Power (MoWP) and the federal Planning Division. The large inter-provincial dams are under the control of Water and Power Development Authority (WAPDA), and the barrages and canal network are supervised by the provincial IDDs. While there are several federal agencies with responsibility for various areas or subsectors of water, there is no appropriate inter-provincial body to oversee integrated water sector planning, development and management. The waters of the Indus River basin are allocated to the provinces through the Water Accord of 1991, which is implemented by IRSA.

Recognizing the need for a new strategy to solve the irrigation and drainage problems, the Government of Sindh adopted a program to establish a self-sustaining irrigation and drainage system. This involves (a) transforming IPDs into Provincial Irrigation and Drainage Authorities (PIDAs); (b)
creating Area Water Boards (AWBs); and (c) organizing farmers into Farmer Organizations (FOs). The Sindh Assembly passed the SIDA Act in 1997. As a result of the Act, the Sindh Irrigation and Drainage Authority (SIDA) was established followed by one AWB on the Nara Canal in 1999. Since then AWBs have been established in Ghotki Feeder and Fulleli/Akram Wah canals. FOs were to be established at distributary/minor canals level to assume responsibility of O&M and collecting water charges. At present there are 359 FOs registered in the jurisdiction of the different AWBs. (SIDA, AWB & FO’s Model placed in Box-3)

Box 3: Irrigation Reforms Conceptual Model:

The SIDA Act was followed by the promulgation of the Sindh Water Management Ordinance in 2002. The SWMO in principle set the stage for a complete rollout of the reform program. The key elements in the proposed reform were the transformation of the IP into an autonomous SIDA, the arrangement of responsibilities on the basis of hydraulic units (canal commands), self-financing of irrigation and drainage services and decentralization of O&M responsibilities to FOs. More than ten years after the passage of the Ordinance, the situation remains essentially stagnant – both ID and SIDA have responsibilities for irrigation management and SIDA still has the three canal commands that were originally assigned to it in the early 2000s. The Regulatory Authority mandated by the 2002 SWMO was never instituted. The Institutional Setup before and after reforms is presented in Box 4, 5 & 6.
Box 4: Institutional Arrangement Before Reforms:

Box 5: Institutional Arrangement After SIDA Act 1997:
Box 6: Institutional Arrangement After SWMO 2002:

FOs that initially showed a lot of promise have weakened and run out of steam: a substantial number of them are in the process of re-election (Table-3). Another indicator is the abiana collection. Whereas in the early years of the reform, when the number of FOs was small, the collection efficiency was high (above 85%), this has gradually tapered off and dropped to low levels (35%). This has left FOs with no funds to maintain the distributaries. The institutional issues related to weakening of reform process are discussed under sub-topic 3.3.

Table-3: No of FOs and election status

<table>
<thead>
<tr>
<th>AWB</th>
<th>No. of FOs</th>
<th>Re-Elections Done</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>GFCAWB</td>
<td>88</td>
<td>48</td>
<td>40</td>
</tr>
<tr>
<td>LBCAWB</td>
<td>93</td>
<td>20</td>
<td>73</td>
</tr>
<tr>
<td>NCAWB</td>
<td>163</td>
<td>88</td>
<td>75</td>
</tr>
<tr>
<td>Outside of AWB</td>
<td>15</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>359</td>
<td>171</td>
<td>188</td>
</tr>
</tbody>
</table>
2.5 Financing of Irrigation Sector

Allocations for O&M by the provincial government are generally made arbitrarily keeping in mind historical trends. The actual allocations depend upon the availability of funds, and seldom match the requirements as per established norms. In comparison, expenditure for the irrigation systems is quite small to the expenditure on police and security.

The irrigation assets are managed by the Department of Irrigation and – in part of the Province – by SIDA. A review of the Irrigation department budgets for the period 1992-2009 shows that a major portion of the budget is used to pay for the system administration and the O&M cost of operating the public tube wells (formerly SCARP tube wells for water logging and salinity control). For example: in year 2009, the total budget allocation was Rs 7,531 million from which Rs 2,991 million (40%) was used for administration, Rs 1309 million (17%) used for maintenance of canals and flood protection embankments, and Rs 3231 million (43%) used to pay the electricity charges for tube wells operation. The latter is particularly high as many tube wells are vandalized (but not yet decommissioned) or unmetered. It suggests that within the low budget cost rationalization is still required. The same applies for staffing. For instance in the irrigation sector the geographical responsibility of an engineer is very high, compared to other countries, with an Executive Engineer responsible for 200-300,000 ha. This area being so large and with a large operational staff and considerable political interference, routine operational issues take large part of the responsibilities for work and there is limited time left for professional water resource management. In other divisions of the irrigation sector by comparison the workload is less and a right-setting exercise will be useful.

Against the expenditures to maintain the vital assets there is income from the irrigation and drainage systems, primarily in the shape of abiana (water tax) and drainage cess (essentially a surcharge on the abiana). This drainage cess is not systematically introduced in areas equipped with drainage. Abiana is assessed and collected by the Revenue Department with the exception of the areas transferred to Area Water Boards. In the latter areas Farmer Organizations undertake the abiana collection, being allowed to retain 40% themselves with the balance transferred to the AWBs.

The method of abiana assessment and collection is outdated. It is based on an assessment of the crop cultivated. This method is laborious and open for errors of judgment and corruption. Moreover, it provides no incentive for efficient water use. Abiana rates per crop bear no seeming relation with the water consumed. Moreover, the water charges per acre have remained constant since 2000 for all major crops, in spite of inflation and price rises. The abiana system as applied by the Revenue Department is suffering from ever increasing underassessment. The total abiana assessed dropped by 43% in the period 2001 to 2010, even though cropped area remained the same and if anything intensity increased (Planning Commission 2012). The collection efficiency in Sindh is high but it is against an ever-declining assessed amount that cannot be logically explained.

In the areas under the Area Water Boards where abiana is collected by FOs and not revenue department the situation is equally unsatisfactory. The recovery rates have been erratic, but the overall trend has been for recovery rates to go down to low percentages.

Due to the limited routine budget for actual work an important part of the investment (including deferred maintenance) is externally funded. For the development and management of
irrigation infrastructure, there have been several past project investments, mostly sponsored by foreign donors including the World Bank, the Asian Development Bank and the USAID. Some of these, such as the On-farm water management project, have proved successful in introducing better water management practices at the farm level. However, management of the canal system and related institutional issues has not received much attention. The only serious effort at institutional reforms was made within the National Drainage Project, which resulted in the Provincial Irrigation and Drainage Authorities in 1997-2007.
3. Issues and Opportunities:

The identification of future irrigation management options must be grounded on a complete analysis of current issues. In the context of Sindh’s irrigation sector, the analysis would include issues related to the institutional framework, deterioration of irrigation infrastructure, degradation of water quality, water-related hazards including flooding, and low productivity in agricultural sector. Further, as we consider these issues, it is important to identify the underlying causes.

The down-stream location of Sindh on the Indus River is a critical factor, as this affects most aspects of irrigation water management in the province. The lack of institutional integration and proper water governance is another cross-cutting factor.

In this chapter, different priority issues are reviewed. The content is arranged by first posing the challenge or problem statement related to each issue, followed by a summary of an assessment of the problem and then outlining opportunities for improvements. In the following chapter, we condense the improvement opportunities into three or four major strategic initiatives or actions that when implemented would address the identified issues.

Box 7: Summary of Priority Issues:

1. There has been constant and far-reaching change in the irrigation systems since its inception that renders many of the current water management arrangement and water allocations redundant- an overhaul is urgently needed
2. The irrigation system is used for a large variety of function far beyond the delivery of water to crops: these other functions (sourcing drinking water, transport, waste disposal, fisheries) are not regulated – yet provided a large opportunity to optimize the multiple purposes of the irrigation sector.
3. The institutional framework for water management is not conducive to good water governance and integrated resource management.
4. The irrigation, drainage and flood protection infrastructure has deteriorated and needs comprehensive rehabilitation and modernization.
5. Agricultural productivity is low, but can be increased through improvements in irrigation and drainage systems and investments that can enhance farmer access to high quality inputs and modern knowledge support.
6. Soil water logging and salinity, caused by over irrigation and inadequate drainage infrastructure, and has rendered large areas of agricultural land unproductive.
7. The risk of climate related hazards including floods, droughts and seawater intrusion has increased in recent years.
8. Present water monitoring and assessment are inadequate, and need to be improved to enhance information generation and its use in decision-making.
3.1 Water Management

3.1.1 Challenge

With non-beneficial evaporation being very high and water logging widespread it is clear that the water management in the irrigation system is seriously deficient. At present there is little practice of water resources management within the irrigation systems and daily activities of the top professional staff is occupied by operational issues.

3.1.2 Assessment

There is much to gain from managing the water resources in the irrigation system. It can contribute to better flood management (with more storage for flood water). It can reduce water logging with many benefits, including freeing up water for use elsewhere in the system. Also a better management of water tables in areas with saline groundwater can create the possibility of creating small fresh water lenses in the upper part of the shallow aquifers. At present this is not happening and in fact political pressure on the irrigation staff causes high deliveries where this is detrimental and wasteful.

3.1.3 Improvement opportunities

Better water resource management should start ‘at the top’ – by revisiting the current practice of surface water delivery to canals and optimize and rationalize the system. This should take into account the natural conditions of the different parts of the command areas, especially the freshness or salinity of groundwater. Especially where groundwater is fresh a good balance between the use of surface and groundwater should be achieved. There is also much scope to improve water resource management within canal systems and on-farm. These should be promoted as they lead to higher yields and they should be supported by awareness and engagement of the main stakeholders to come to a common understanding and appreciation of issues.

In addition, we have to adopt Climate Resilient Integrated Water Resources Management. “Climate Change” translates into extreme events of high river flows resulting from severe rain storms, coupled with excessive glaciers snow melt and droughts due to no rains and glaciers retreat. Climate resilient water resource management will, therefore, involve adaptation and readiness for floods and droughts.

Flood Disaster Management techniques should be employed at On Farm Water & Drainage Management Level, including flood warning rescue & relief operation, adaptation by the affected persons & Raised Platform Shelter for flood affected.

Intensive and extensive training in flood management would be given to the irrigation and OFWM staff and general public living in flood prone areas.

For drought conditions, agriculture will have to adapt to crops with low water requirement. The storages and ground water reservoir, developed in suitable areas, will come in handy in drought conditions.
3.2 Multi-functional use

3.2.1 Challenge

The irrigation system is the defining element of the rural landscape of Sindh. It provides irrigation water but also serves so many other purposes. Water is used for agriculture but also for fishery, water supply for towns, villages and industries and for bathing (animals), washing and laundry. The network of canals and embankments is used besides the transport of water for navigation, for planting trees and for local transport over the inspection roads and for collecting sand during canal closure periods. The irrigation system has a tremendous impact on soil moisture as well, particular in Sindh on water logging and related to it salinity. The irrigation and drainage system also are main factor in public health: high water tables for instance cause a range of human and livestock diseases and for instance preclude the development of latrines.

3.2.2 Assessment

All these other functions are mainly unmanaged. A most significant manifestation is the uncontrolled discharge of pollutants in irrigation canals, severely affected public health downstream. Another manifestation is that of ‘opportunities foregone’. There is much scope to make better use of the canal systems for other functions as well. An example is for instance tourism or water front property development. One can take the example of Keenjhar Lake that is within relatively short distance from Karachi and can serve as a well-developed destination of day tourism. By doing so jobs would be created and valuable income for the irrigation sector could be generated.

3.2.3 Improvement opportunities

The multifunctional use of the irrigation systems should be systematically developed and addressed. There are several priorities: (a) reducing the pollution from industries, sugar mills and urban areas to the irrigation water; (b) development of interceptor drains along all main canals, on the principals of “Water Use & Re-Use”. (c) Developing main income generating opportunities such as canal bank forestry and tourism and property development. A special highly mandated task force should be assigned the responsibility to develop the plans and corrective action in this regard.

3.3 Institutional Framework

3.3.1 Challenge:

The administrative structure currently in place is not conducive for improving irrigation water management in the province. It does not ensure optimal use of the province’s canal and groundwater resources in meeting its diverse needs including irrigation for food production and security, while managing floods and droughts. There is a large amount of outside interference in the workings of government departments by large landowners, which results in mismanagement of the irrigation system and available water supplies.

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7 Master Plan Phase-II report contains a prefeasibility study titled Sugar Mills Effluent Treatment at Source.
3.3.2 Assessment:

The team was informed in the stakeholders’ workshops that the irrigation sector’s institutional framework suffers from a lack of integration, administrative autonomy, financial controls and that coordination among related authorities is weak. There is limited communication between the provincial Departments of Irrigation and Agriculture and other agencies concerned with land, water and agriculture. The promised reforms through the implementation of the 1997 SIDA Act have not materialized.

The 1997 Act, established SIDA for reasons: a) to promote participatory irrigation governance including FOs and WUAs, b) to emphasize the equal importance of drainage, given the ever-increasing problem of water logging and salinity, and c) to rehabilitate and upgrade irrigation network infrastructure. After 15 years, SIDA has remained static with the originally three canal commands assigned to it for improvements. The result is the duplicate use of government resources, unproductive rivalry between SIDA and ID, and inefficient service for the water users. There is an urgent need to resolve this issue and identify ways forward for successful conclusion to the 1997 PIDA Act. One way to analyze this issue is by asking: what went wrong?

- Either the idea was incorrect, or
- The idea is sound but was implemented incorrectly.

Our working hypothesis could be that the idea behind the reform initiative is fundamentally correct. Government departments simply cannot continue to absorb the full O&M cost of system. The Irrigation Department can manage Interprovincial water distribution and policy matters. However, it makes perfect sense to ask water users to assume the responsibility of managing the small-scale infrastructure, through WUAs at water course level and FOs at distributary and minors. The Area Water Board, with mix of technical staff, academia, and farmers representation from middle and tail areas of main canals, can supervise canal water distribution and maintenance, and SIDA governed by its board with participation of executives, engineers, farmers and researchers, was assigned to take care of water distribution inside province at Barrage Level. Hence, the 1997 Act recommended for farmers to organize in FOs and WUAs to undertake tertiary system O&M. The other reason behind the SIDA reforms is to highlight the importance of drainage in irrigated agriculture. In the Indus Basin and especially in Sindh, with flat topography and alluvial soils, excess surface water (from irrigation and rain) does not drain to a sink; it primarily infiltrates into the subsoil. This inefficient irrigation application at farm combined with seepage from irrigation canals has resulted in the menace of water logging and salinity in the Indus Basin. It is important for all stakeholders to recognize this causative relationship between irrigation and drainage, and to always think of irrigation and drainage as two essential parts of irrigated agriculture, especially in downstream river basins with arid climates and flat topography.

Assuming that the idea is fundamentally sound, and then something went wrong with its implementation. Did the original plans call for a transformation of ID to PIDAs? Or, the PIDAs, AWBs and FOs were to function as self-sustained autonomous bodies and Irrigation Department was to play its part as inter-provincial stake holder for water distribution? What components of 1997 Act worked well and what did not work so well? The team’s understanding from various meetings and workshops is that the FOs and WUAs have worked well. Initially, their administration was well received by farmers
as they could achieve a satisfactory level of water distribution equity. The irrigation fee recovery improved and FOs and WUAs became well known in rural Sindh. However, one big problem was at one level up the system, where the FOs received water from the AWBs. AWBs, for several reasons, have not functioned well and could not reliably deliver allocated water amounts to FOs.

The core issue identified during consultative meetings is near exclusive control of distribution system by ID, the engineering staff from Executive Engineers up to Tandials (Gate Keepers) are still under administrative and financial control of ID. This is against the principle of IWRM.

Before inception of WSIP, the Managing Director and Staff of SIDA, Directors and Institutional staff of AWBs were also under same state, but now they are appointed by governing board from open market through transparent procedure. The Reforms in Sindh are still in transition phase, the only option seems to be continuity. The Election process of AWBs and SIDA Board farmer members should be continued on regular basis, at present they are selected by GoSindh on regular basis.

Box 8: Quote on Democracy and Empowerment:

> “People shouldn’t be afraid of their government. Governments should be afraid of their people.”
> – Alan Moore, *V for Vendetta*

Another major problem that ID officials reported to the team is their inability to effectively perform their job because of our Socio Economic Culture. The influential misuse their power to influence ID’s operations including appointments of irrigation engineers, getting direct outlets on the main canals, and water deliveries to farmers. This results in extreme inequity in irrigation water distribution. The large farmers, usually with upstream locations on irrigation canals, take unauthorized large water quantities leaving little or no water for the downstream located small farmers. This issue is very effectively handled by SIDA and AWBs, where Farmers are involved in decision makings, like Canal Regulation, Irrigation Scheduling (Wara-Bandi) and De-Silting. The Tail-End Areas of Nara Canal e.g Thar Division is well irrigated after proper implementation of reforms and rehabilitation of main canals under WSIP. The Farmers of Noor-Wah Tail, awarded their AWB Executive Engineer with a Gold Medal.

The Water Accord and IRSA (Indus River System Authority): One important issue relates to the sharing of water among the provinces. Because there are legitimate but contending views from different parties, agreement on principles for inter-provincial water sharing is difficult, everywhere. In this light, the 1991 Water Accord is a major achievement that has worked well for all provinces. It is important to understand and support this Accord, since many people in Sindh complain that Sindh does not receive its fair share of water. This perception is largely incorrect, as the water allocation according to the Accord is fair and mostly in Sindh’s favor.

The water accord defines three distribution patterns for allocating water among the provinces as shown in Table 1. It is a good blend of the two principles governing trans-boundary waters. The principle of “No Appreciable Harm” is applied to prior (historic) uses, and the “Principle of Equitable Utilization” is applied to both future water developed and to periods of abundant water availability.
There are some ambiguities in the 1991 Accord especially relating to what constitutes “initial conditions” because allocations when there are shortages and surpluses are quite different. In the view of Punjab Province, paragraph 2 was contingent on the building of additional storage, and since additional storage has not been built, it is paragraph 14b that defines the starting point. In the view of Sindh Province, it is paragraph 2 that constitutes the initial conditions (Table-4).

Table-4 : Flow distribution among provinces (%)

<table>
<thead>
<tr>
<th>Province</th>
<th>Para 14(b)</th>
<th>Para 2</th>
<th>Para 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Punjab</td>
<td>53.1</td>
<td>48.9</td>
<td>37</td>
</tr>
<tr>
<td>Sindh</td>
<td>42.2</td>
<td>42.6</td>
<td>37</td>
</tr>
<tr>
<td>KPK</td>
<td>3.0</td>
<td>5.1</td>
<td>14</td>
</tr>
<tr>
<td>Balochistan</td>
<td>1.6</td>
<td>3.4</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

The accord has been implemented for 23 years with a considerable degree of success. The members of IRSA have developed a formula for interpreting it that works though not without fueling mistrust. The formula is to provide water depending on the level of availability in the river system (Figure-8). In the low-availability scenario, where water availability is less than actual average system uses, water is distributed as per paragraph 14 (b) of the accord. In the medium-availability scenario, where water availability is greater than the actual average, but less than paragraph 2 of the accord, historic uses are protected as per paragraph 14(b) with the balance distributed as per paragraph 2. In the high-availability scenario, where water availability is greater than paragraph 2 up to the limit defined therein, the allocations are as per paragraph 2, and any excesses are distributed per paragraph 4 of the accord.

Figure 8: IRSA’s De Facto Rule for Water Allocation (FoDP, 2012)
Since its inception, IRSA had no financial independence and has been unable to finance its operations and staff. Recently, however, an important agreement has been reached that IRSA will receive earmarked budgets from levies on water delivered to the provinces and on energy generated.

Sindh should support this arrangement, as this will provide a sustainable financial basis for IRSA. Another major ongoing controversy is over measuring flows at both the barrages and at the heads of the main canals. These measurements are the responsibilities of the provinces. In principle, other provinces place officials to “check” these measurements, but this arrangement does not work. A decade ago a telemetric system was installed to automate the measurement and reporting process, but it has not worked. Sindh should support installation of modern flow measuring equipment along the Indus so that accurate information is available related to water availability, flows at various barrages and diversions into main canals.

3.3.3 Improvement Opportunities:

We do not recommend dismantling competent and highly experienced entities currently working in the irrigation sector, mainly ID, the DoA and SIDA. However, it would be beneficial if these agencies would work together, coordinating work programs and developing interventions to improve irrigation water management. It is a huge task to have a proper split and integration of institutional roles at different levels influenced by political, legal and technical constraints. For Sindh’s irrigation system, current phase is of better coordination, filling-in the gaps and capacity building of the public and private institutions involved in the irrigation sector. The issue of ID and SIDA is of particular importance, which needs to be resolved urgently. This will need careful study and analysis. Given the limited amount of time available for this study, the team is not in a position to make definitive recommendations. It is recommended that the Sindh Government establish, on a priority basis, a task force, with a clear mandate and adequate resources to resolve the PID-SIDA issue and formulate the most effective institutional framework for irrigation management.

The issue of outside interference is very difficult to resolve as the underlying cause is the existence of many large landlords, since the land reforms of 1960s were not genuinely implemented in the Sindh Province. Comparatively, in Punjab, the land reforms were correctly implemented with the result that the land ownership on distributary canals is not as skewed as in Sindh. FOs, WUAs and especially AWBs can perhaps maintain a reasonable level of water distribution equity, but the real and permanent solution is to implement genuine land reforms in Sindh. Until this happens, mobilizing farmers to organize and participate in the workings of the FOs and WUAs is of critical importance.

3.4 Infrastructure Platform

3.4.1 Challenges:

The IBIS, including that in Sindh, depends heavily on proper functioning of its major infrastructure. All three barrages in Sindh where water is diverted from the Indus River into the main canals are 60-80 years old. Much of the canal infrastructure including water control gates and mechanical movements are more than 60 years old, and are not functional in many cases. In Sindh, the canal infrastructure has been operated at capacities much higher than their designs, which has led to serious structural deterioration at all levels of the canal network. There is very little storage capacity in the canal network of the Indus Basin. In one of the largest rivers in the world, there is only one
major reservoir on the main stem of the Indus. Within the canal network, there is no storage capability and all water diverted from the river must flow through the canal network, eventually arriving at the farm.

3.4.2 Assessment:

Pakistan, to a large degree, and especially Sindh are built around a single river. It is naturally an environment of extremes, with large seasonal and annual variations. About 70% of the flow in the upper Indus occurs in just 3 months of the year. The richer countries with rivers flowing through arid landscapes, have built many large dams and reservoirs to reduce peak flows, conserve water and mitigate floods and droughts.\(^8\) The requirement for major storage in the Indus Basin has been clear since the founding of Pakistan (FoDP, 2012). With the signing of the Indus Water Treaty in 1960, there was a political consensus within Pakistan and between Pakistan and its development partners on the urgent need for storage. Tarbella and Mangla Dams would, together, be able to store only 30 days of the combined average flow of the Indus, Chenab, and Jhelum rivers (Figure-9). It was expected that a new reservoir the size of Tarbela Dam would be built every decade for the foreseeable future (Lieftinck Report, 1968)\(^9\). Unfortunately, 50 years later only two minor additions have been made – some additional hydropower generating capacity at Ghazi Barotha and the recent raising of the Mangla Dam.

Figure-9. Water storage in various river basins (days of average flow they can hold)

Source: FoDP Water Task Force (2012)

At water delivery and distribution level, primarily as a result of excess flows, the canals are not working as non-silting and non-scouring “regime” channels, but have eroded and silted in many places. The excess canal flows have become necessary since many farmers are choosing (against regulations to the contrary) to plant rice and sugarcane. Even in the Ghotki, Nara and Rohri Canal

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\(^8\)In the Colorado River in USA, and in the Murray Darling River in Australia, reservoirs have the capacity to store about 1000 days of average flow. Tarbella and Mangla can store only 30 days of average combined flow of Indus, Chenab and Jhelum.

areas, which are designed to support cotton and were large cotton growing areas in the past, large majority of farmers are now growing rice and sugarcane. This situation needs to be changed somehow. The farming community can be encouraged to grow less water consuming crops; grow rice but with better water and crop management practices (e.g. SRI); or they can pump groundwater for their increased water needs. Also, the canal network, as a result of high discharges, is in urgent need of comprehensive repairs and modernization

3.4.3 Improvement Opportunities:

i. Rehabilitate and modernize barrages and the canal network: Rehabilitation and upgrading of barrages should be the top priority. Canal network and related control structures need rehabilitation and modernization, especially including modern ways to measure water flows and communicate the information to water managers in real-time. Direct outlets on the main canals must be removed. Also, human settlements in the right-of-way of the canals, and sometimes on the canal banks, must be removed.

ii. Increasing storage capacity on the main Indus: To increase the assured yield of the irrigation system, the most important objective would be to increase storage on the main stem of the Indus. For this, Basha Dam (with live storage of 6.4 MAF) is key, with Dasu (live storage of about 1 MAF) playing a supporting role. Storage capacity is equally vital for flood control. Even though Tarbela Dam is operated primarily to meet irrigation demands, it helped considerably buffer the effect of the massive 2010 floods. Basha and Dasu dams will add considerably to the capacity to control floods on the main stem of the Indus, which will be very beneficial for Sindh.

iii. Increasing storage capacity in the canal network: Within the canal network, storage is also vital for enhancing productive use of irrigation water. This storage can be in the form of small reservoirs built off-line on branch and distributary canals that can hold water when not needed by farmers and release it when needed. They are better conceptualized as “equalizers”. These off-line storages can also be used to harvest rainwater.

iv. Invest in modern approaches to estimating water availability and measuring and reporting water deliveries to main canal and losses. There are major, ongoing controversies over measuring flows at both the barrages and at the intake of the canals and down the canal (water distribution to branch and distributary canals). Also, measurement of water losses in the river and the canal network is very important. There are serious controversies about the 20 MAF of water in the system that is “lost” in conveyance between the barrages and the canal head works. This number has doubled over the last decade, although there have been no changes in flows or stream morphology. Some evidence is that unauthorized abstractions are growing rapidly and are not accounted for. There is an urgent need for an independent, technical assessment of what these “losses” comprise.

10During the 2010 floods, the maximum flow into Tarbella Dam was 835,000 cusecs and released controlled flow downstream that went up to 604,000 cusecs, a reduction of about 30%. This saved the downstream river areas from even greater suffering.
3.5 Drainage of Agricultural Lands

3.5.1 Challenges:

Water logging and salinity are pronounced problems in Sindh, and pose a major threat to sustainability of irrigated agriculture on about 30 percent of irrigated lands. This situation is aggravated by inefficient irrigation practices at farm level, seepage from earthen canals, flat land topography and the lack of drainage facilities. Water logging also creates major public health hazards and damages adobe houses. It is estimated that water logging and salinity has reduced crop production by 40 to 60%\(^\text{11}\). Soil-water salinity in Sindh has also increased with the expansion of irrigated area. In saline ground water areas, salt content is very high – about 4,000 ppm; while in fresh ground water areas, the salinity level is much lower – about 920 ppm. Figure 10 shows the extent of soil-water salinity problem in the Indus Basin, with major problem areas in Sindh. Why an efficient and secure drainage network for Sindh? The Master Plan Report for Left Bank of River Indus, Phase-III, answers: “It is estimated that 20 million residents of interior Sindh depend on irrigation water for their domestic use, especially in areas where the groundwater is brackish. The contamination of irrigation water by coliform bacteria exceeds the limits set by W.H.O”\(^\text{12}\). About 300 water samples from water bodies of three southern districts Thatta, Badin and Tharparkar were tested measuring physical, chemical, and biological (total coliform) quality parameters. All four water bodies (dug wells, shallow pumps, canal water, and water supply schemes) exceeded World Health Organization (WHO) MPL for turbidity (24%, 28%, 96%, 69%), coliform (96%, 77%, 92%, 81%), and electrical conductivity (100%, 99%, 44%, 63%), respectively. Iron was major problem in all water bodies of district Badin ranging from 50% to 69%. Some common diseases found in the study area were gastroenteritis, diarrhea and vomiting, kidney, and skin problems (Memon and Soomro, 2010)\(^\text{13}\). A recent study conducted by the Indus Institute for Research and Education (IIRE) on groundwater quality in Sindh has portrayed the groundwater situation of Sindh at large. The scenario of the groundwater quality with respect to the left bank area is presented in Table-5.

Table-5: Level of TDS of the Groundwater in Left Bank area

<table>
<thead>
<tr>
<th>Sr.#</th>
<th>District</th>
<th>Samples Tested</th>
<th>Samples mg/l &lt;1000 TDS</th>
<th>Samples mg/l &gt;1000 TDS</th>
<th>% samples with High TDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ghotki</td>
<td>8</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Sukkur</td>
<td>15</td>
<td>12</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>Khairpur</td>
<td>15</td>
<td>13</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>Naushero Feroz</td>
<td>15</td>
<td>13</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>5</td>
<td>Hyderabad</td>
<td>20</td>
<td>17</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>Thatta</td>
<td>16</td>
<td>10</td>
<td>6</td>
<td>38</td>
</tr>
<tr>
<td>7</td>
<td>Badin</td>
<td>19</td>
<td>9</td>
<td>10</td>
<td>52</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sr.#</th>
<th>District</th>
<th>Samples Tested</th>
<th>Samples TDS mg/l &lt;1000</th>
<th>Samples TDS mg/l &gt;1000</th>
<th>% samples with High TDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Tharparkar</td>
<td>18</td>
<td>3</td>
<td>15</td>
<td>83</td>
</tr>
<tr>
<td>9</td>
<td>Umerkot</td>
<td>10</td>
<td>6</td>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>10</td>
<td>Mirpurkhas</td>
<td>11</td>
<td>7</td>
<td>4</td>
<td>36</td>
</tr>
<tr>
<td>11</td>
<td>Sanghar</td>
<td>17</td>
<td>11</td>
<td>6</td>
<td>35</td>
</tr>
<tr>
<td>12</td>
<td>Nawabshah</td>
<td>14</td>
<td>11</td>
<td>3</td>
<td>21</td>
</tr>
</tbody>
</table>


Maximum Permissible Limits: TDS=<1000 mg/l, Arsenic=0.05 mg/l, Lead=0.05 mg/l, Zinc=5.0 mg/l, Cadmium=0.01 mg/l

The un-seen aspect of above described ground water contamination is absence of provincial drainage network. The Municipal Drainage systems outfalls in depressions outside cities or in irrigation channels.

In purview of storm water drainage of agriculture drainage, the Master Plan Report describes 2011 Rain Flood Scenario Box-9:

**Box 9:**

“According to FAO and SUPARCO estimates, about 1.83 million acre (2850 sq. miles) land was inundated in four districts on 1st of October, after 2 weeks of last rainfall event. Other than Nawabshah, where it was 32% of the area supported by LBOD, inundated land was more than the areas provided with drainage through LBOD. Obviously, some inundated area was outside the LBOD command. On 18th of October, estimated inundated area was about 1600 sq. miles or 57%. Other than evacuation through LBOD network, water moved to the lower areas, pumped out to irrigation channels by the farmers. The areas with trapped water decreased slowly, mostly through pumpage because discharge through gravity declined. Two additional factors influenced drainage operation, but are beyond the design perceptions of the system. Large quantities of runoff generated outside the network found evacuation route through LBOD network”.

3.5.2 Assessment:

In Sindh, irrigation water losses are high, as about 76-80% of the diverted water is lost to non-beneficial uses (seepage and surface evaporation). The seepage from canals and the deep percolation losses at the farm are major contributors to the rising water tables and soil salinity. The groundwater recharge occurs over both the fresh groundwater zones and saline groundwater zones of the province at a ratio of 25:75 by area. In spite of the fact that almost all agricultural lands are flat with very low natural drainage capability, farm-level drainage facilities are very limited.

From 1960s, the Salinity Control and Reclamation Projects (SCARP) were implemented, starting in Sindh with the Khairpur project. The main philosophy was vertical drainage and lowering of water tables by drilling tube wells and pumping water. The programs delivered the goods, but the
main challenge was the continued operation and maintenance and the adequate funding thereof. By now the SCARP systems have aged and only a small proportion is functional. More recently considerable investments were made under LBOD, partly completed under the National Drainage Program. This concerned tile drains, drainage tube wells, scavenger wells and a network of open drains. Again the main challenge was the maintenance and performance is not dissimilar to the SCARP tube wells. The high non-functionality (70-90%) applies to LBOD as well and gives a clear message to be very judicious in drainage investment\(^\text{12}\). At present the Right Bank Outfall Drain (RBOD) is still under construction.

**Figure-10: Salinity hazard in the IBIS**

In Sindh, the high irrigation duties boosted by additional supplies and the *Puncho* system of flood irrigation are wreaking havoc on soil quality and its long-term health. The lower left bank areas of the Indus (Badin and Thatta) are the premier problem spots in this respect and are water management disaster (Figure-10). The high saline groundwater here is very much in the root zone. Water logging and salinity continue to persist due to the high irrigation supplies and the flat

\(^{12}\) The experience from LBOD moreover was also that due to the uncertainties in establishing the drainage coefficient in some areas, ‘too much’ drainage facilities were foreseen and that even before all facilities were operational the system was in balance again
topography plus deteriorating natural drainage due to the tidal effect moving upstream after the scouring out of the Tidal Link. The impact concerns not only agricultural productivity but also basic drinking water supplies. The main source of drinking water is the highly polluted water in the three main left bank irrigation canals. The situation in Badin and Thatta further deteriorated after the 2011 floods consolidated and further spread the high water tables.

3.5.3 Improvement opportunities:

Proper drainage of agricultural lands is a huge problem in Sindh, but correctly approached, there are a number of opportunities. First, the source of excess water must be reduced, which is the large amount of seepage from irrigation canals and the inefficient application of irrigation water at the farm. The very first priority is to re-evaluate the high irrigation duties and the even higher diversion. Unless this is rationalized investment in drainage or other water saving measures makes no sense. A special expert task force is required to reassess the irrigation duties, bring them in line with the fresh-salt water balance in the area so as to maximize the use of water.

The next step is to work on water use efficiency further down in the system. The Directorate of On-Farm Water Management has successfully implemented water course lining and better on-farm water management practices including precision land leveling and non-flooding ways of water application to the land (basin and furrow-ridge methods). The adoption of drip irrigation is the next logical step in this direction. The Punjab OFWM Directorate has made significant advances in its introduction, and their “High Efficiency Irrigation Improvement Program” is already connecting farmers to the private industry groups to provide drip irrigation technology to the users.

Second, the government should consider a selective program to provide drainage facilities to the farmers. It can revive and strengthen the SCARP tube well program, and it can provide sub-subsurface tile drainage infrastructure. The challenge is to this in a cost effective and cost sharing manner. The problem with land drainage is that it can’t be done on a private basis, but must be done on a “public good” basis since an individual installing sub-surface drainage will not affect ground water levels. The whole delta region of the Nile River in Egypt was provided a comprehensive land drainage system in the form of sub-surface tile drains, collector open drains and the outfall drain to the Mediterranean Sea. It is now one of the most productive agricultural lands in the world. All farmers are paying back the cost in the form of increased land tax.

In addition the larger drainage picture should be safeguarded. There are a number of guiding principles in storm water drainage:

- Priority should be given to unblocking surface drains closed by roads and railway tracks and make adequate cross drainage on new and old infrastructure compulsory.
- Isolated Areas should be connected with existing drainage networks.
- In some cases local dugouts may also serve to lower groundwater tables and as local freshwater storage – such as borrow pits from construction
- Care should be taken not to ‘over drain’ and make sure water tables are lowered but not to too large a depth; so that the beneficial effects on soil moisture from water tables are safeguarded.

In addition for root zone drainage:
The source of excess water must be reduced, as discussed before. In addition to rationalizing surface water deliveries, lining vulnerable channel sections will reduce canal seepage. The Directorate of On-Farm Water Management has successfully implemented watercourse lining and better on-farm water management practices including precision land leveling and non-flooding ways of water application to the land (basin and furrow-ridge methods). The adoption of drip irrigation is the next logical step in this direction.

The main aim is to create enough storage space in the upper soil layers to ensure adequate soil aeration for crop growth and ideally in saline areas allow the development of fresh water lenses that can be used for local drinking water systems. In addition, this root zone aeration would help to avoid rainfall flooding as was observed in 2011 on left bank areas.

It is important to revive the existing facilities, especially in saline groundwater zones. There is no reason at all to develop or maintain public drainage facilities in fresh groundwater zones, as normally most of the drainage requirement would be taken care off by private pumping in such areas.

Ideally, where root zone drainage is provided there should be the possibility of flexibility in water levels and no uniformity: some crops (rice) can tolerate high water tables and for other crops sub-irrigation is beneficial. It is better to have a controlled drainage system that accommodates the different requirements.

There should constructive cooperation between farmers and government. There are by now several examples of farmers maintaining and even in investing in drainage facilities. Joint agreement and support in the provision of sophisticated O&M needs to be there.

Finally, biological drainage – in particular the promotion of eucalyptus tree stands – needs to be more systematically promoted. It is understood that at present farmers often do not replant their eucalyptus trees because of the effect of the trees/leaves on the soil fertility. This requires the introduction of other eucalyptus varieties and also the promotion of local concentrated eucalyptus forest rather than isolated stands. The details of tree species that can be planted for biological drainage and to control land degradation are described in Table-6:
### Table-6: Indigenous tree/shrub species for plantation in areas affected by desertification in monsoon season

<table>
<thead>
<tr>
<th>Local Name</th>
<th>English Name</th>
<th>Botanical Name</th>
<th>Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>Babul</td>
<td>Acacia</td>
<td>Acacia nilotica</td>
<td>Leguminosae/Mimosoideae</td>
</tr>
<tr>
<td>Kunbhat</td>
<td>Gum Arabic</td>
<td>Acacia Senegal</td>
<td>Leguminosae/Mimosoideae</td>
</tr>
<tr>
<td>Bavri</td>
<td>Amartasar gum</td>
<td>Acacia Jacquemontii</td>
<td>Leguminosae/Mimosoideae</td>
</tr>
<tr>
<td>Phulai</td>
<td>Neem</td>
<td>Acacia modesta</td>
<td>Leguminosae/Mimosoideae</td>
</tr>
<tr>
<td>Nim</td>
<td>Indian Bdellium</td>
<td>Azadiradita indica</td>
<td>Mimosoideae Meliaceae</td>
</tr>
<tr>
<td>Gugur</td>
<td>Calligonum</td>
<td>Commiphora mukul</td>
<td>Burseraceae</td>
</tr>
<tr>
<td>Phog</td>
<td>Narrow leaf sepistan</td>
<td>Calligonum polygonoides Cordia</td>
<td>Polygonaceae</td>
</tr>
<tr>
<td>Lyar</td>
<td>Caper</td>
<td>latifolia</td>
<td>Ethretiaceae</td>
</tr>
<tr>
<td>Kirir</td>
<td>berry</td>
<td>Capparis deciduas</td>
<td>Capparidaceae</td>
</tr>
<tr>
<td>Kandi</td>
<td>Prosopis</td>
<td>Prospis cineraria</td>
<td>Leguminosae/Mimosoideae</td>
</tr>
<tr>
<td>Devi</td>
<td>Mesquite</td>
<td>Prospis juliflora</td>
<td>Leguminosae/Mimosoideae</td>
</tr>
<tr>
<td>Jaar</td>
<td>Tooth brush Tree</td>
<td>Salvadora persica</td>
<td>Mimosoideae</td>
</tr>
<tr>
<td>Mithi</td>
<td>Tooth brush Tree</td>
<td>Salvadora oleoides</td>
<td>Salvadoraceae</td>
</tr>
<tr>
<td>Jaar</td>
<td>Tooth brush Tree</td>
<td>Tecomaria</td>
<td>Salvadoraceae</td>
</tr>
<tr>
<td>Rohiro</td>
<td>Tecomaria</td>
<td>Bignoniceae</td>
<td>Coniferae</td>
</tr>
<tr>
<td>Lai/Lao</td>
<td>Tecomaria</td>
<td>Rahmnaeseae</td>
<td>Rahmnaeseae</td>
</tr>
<tr>
<td>Ber</td>
<td>Tecomaria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jaanguri ber</td>
<td>Desert Jujube</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Given the investment costs and challenge of sustainable operations, investment in drainage however is the measure of last resort targeted at the areas that most need it – where possible the
problem should be prevented by better managing surface supplies. In addition there is an urgent need to restore natural drainage path that are now often blocked by road and railway development or urban expansion.

3.6 Protecting the Resource Base – Floods and Droughts

3.6.1 Challenges:

The frequency and severity of floods in Sindh seems to have increased in recent times. Sindh is now living through an extraordinary post-flood reality, with two of the largest floods on record occurring in 2010 and 2011 with a third flood of lesser proportions occurring in 2012, 2013 and 2014. The 2010 Floods originated with Cloud Burst on catchment areas of Kabul River, finally reaching at Guddu, these flows resulted in two major breaches at Tori and Sujawal. The 2011 was similar incident on South Eastern Part of Sindh, but it was on cultivated area. The Volume of down pour was equaling to twice the storage of Tarbella Dam (Annex-A). The 2012 was again same kind of scenario at north western parts of Sindh. The 2013 & 2014 Floods were of medium level, occurred due to release of flood water from Indian controlled rivers of Punjab, ultimately reaching Indus.

3.6.2 Assessment:

Sindh is basically a delta over which the Indus has meandered over millennia. Before human intervention, the Indus meandered because as silt built up in its bed, it sought, like alluvial rivers everywhere, lower lands and a new channel. This natural process is not compatible with human settlements, and so throughout the world, such rivers have been trained and confined by embankments within relatively narrow beds. In this case the bed keeps getting higher and higher, and soon the river is above the level of the land, as in the lower parts of Sindh. Over time the likelihood of embankment breaching increases as do the problems of drainage from flooded lands. When this coincides with unfavorable tidal conditions in sea, the consequences can be disastrous. And, this is what happened in the floods of 2010. The floods were triggered by unusual rainfall events – which are attributed to changes in high-level weather circulation associated with climate changes. This could mean that such events repeat themselves.

Both banks of the Indus River in Sindh are vulnerable to damage caused by floods as the river flows centrally through the province. This is aggravated by the conversion of the flood plains into areas of permanent cultivation – restricting the space for the river in flood. Both riverbanks have been provided with flood protection embankments, but the flood protection infrastructure is generally not properly maintained. People have built settlements in the right-of-way and very close to the dykes, sometimes on top of the embankments. This makes proper maintenance almost impossible.

Agriculture Practices in river flood plains used to be a normal practice, but on principal of not disturbing the river bed topography. The renowned Agriculture Engineer and Researcher M.H. Panhwar, who was quite a supporter of River Bed development, was also cautious about its over-exploitation and permanent settlements in water way.

It is worth highlighting few major challenges, which came to the fore in 2010. Embankments are major structures for flood management, similar in many ways to large dams and barrages. Lack of maintenance of embankments and encroachment of flood plains is a very serious institutional and
financial issue. An illustrative case is that of the Tori Bund, which collapsed in 2010 with catastrophic consequences. As with many other embankments, there had been little regular maintenance over the years, and the embankment was in fragile condition before the flood.

The 2011 Rain Floods on south eastern parts revealed that the areas connected with LBOD drainage system were drained out in just a month’s time and wheat crops were cultivated in time. The remaining isolated portions were under water for almost 6 months. The GIS Image analysis is attached at Annexure-B. The International Consultants for Master Plan of Left Bank of Indus, Delta and Coastal Zone did detailed studies on this issue. The event of 2011 floods is described in Box-10:

**Box 10: Performance of available drainage facilities in left bank during 2011 rain flood event**

"The lower part of Sindh received ever maximum monthly rainfall during August and September 2011. The average rainfall was about 300 mm with duration of 24 – 48 hours and was 2-3 times higher than the land drainage capacity of existing drainage system. The heavy rainfall in Districts of Badin, Mirpurkhas, Tando Muhammad Khan, Nawabshah and Sanghar generated runoff of 15000 cfs, while LBOD system is designed for a discharge of 4600 cfs. The above districts were inundated with a depth of storm water ranging from 3 to 4 feet. The LBOD system performed satisfactory though there was limited capacity, obstructions and encroachments to natural drainage and overtopping/breaching at number of places was reported. The high level of water in Spinal drain caused submergence of Mirpurkhas Main Drain in city area of Mirpurkhas and LBOD branch drain resulting inundation of adjoining villages and towns of Badin and created havoc with the life and property in above areas. The outfall drains of KPOD and DPOD were running with a discharge of 7000 cfs and 4000 cfs respectively much above their design capacity”.

The LBOD system performed well in southern portion, as its command area was cleared up in just one month (Annexure-B &C). The reason of comfortably passing high discharge was its evolution as Natural River, which has enhanced its cross sections and developed several creeks on its left side in Run of Kutch (Annexure-D).

The basic problem identified during rain floods of 2011 and 2012 was obstruction in natural water ways and zero O&M/ ownership of already available infrastructure

**3.6.3 Improvement opportunities:**

The history of human civilization is largely a history of development in river basins and an associated bargain between benefits (the relative ease in obtaining food security, transport and energy services) and costs/threats from periodic flooding. Damages caused by floods are, therefore, not necessarily a failure of policy or execution, but in part a rational choice made by people who live in flood plain. There has long been an understanding in Sindh and Pakistan of the devastating impact of floods, and there are long-standing efforts to manage floods better. Institutions, including the Federal Flood Commission (FFC), have been established, and there have been large donor-financed projects dealing with understanding floods, predicting, planning, warning, and post-flood recovery.
Because of the catastrophic consequences of failure of a large dam or barrage, as in most countries, there is a centralized technical entity, which is responsible for monitoring these structures and reporting on the findings to the responsible political and administrative entities. At present there is limited capability for the large embankments, despite the obvious parallels in terms of the need for specialized technical expertise, and the consequences of failure\textsuperscript{13}. The team recommends following priority actions in relation to management of embankments.

- Our Water Ways must be cleared from all kind of encroachments.
- Assign the Irrigation Department or SIDA greater accountability and capability for maintenance and operation of flood infrastructure. This includes developing asset management plans and the commitment of dedicated resources.
- Creation of Barrage Management Organization (BMO) within ID and engaged as a specialized third party using up-to-date technology to inspect the embankments on a regular basis.
- Repair existing damaged embankments and control all embankments with regards to durability and possible invisible damage.
- Construct new priority embankments to complete the network in order to achieve maximal security for people.
- Work on an inventory database of embankments and breaching sections, document their current condition and take into consideration the obtained information in danger and hazard maps.
- Assess the main encroachment/obstructions in the flood plains/water way and start the process of removing these.
- Consider adding regular inspection of major embankments to the mandate of the WAPDA dam safety unit.
- The Master Plan Consultants under WSIP has prepared detailed feasibilities studies for using Natural Water Ways/ Dhoras as feasible option for drainage of isolated portions of Left Bank of Indus and some other interventions for livelihood enhancement of coastal belt. The list of Feasibility Studies are as follows:
  - Rehabilitation & Improvement of LBOD Infrastructure.
  - Revival of Natural Water Ways to evacuate Storm Water.
  - Protective Plantation of Mangroves in Coastal Areas to check Sea Intrusion.
  - Use of Drainage Water for Forestation in LBOD Command Area.
  - Promotion of Brackish Water Fisheries in Outfall Areas.
  - Shrimp and Mud Crab Farming in Coastal Areas.
  - Bio-Saline Agriculture in Badin and Thatta Districts.
  - Rehabilitation of Coastal Wetlands.

Two separate Plans to contain Tidal Link area are also prepared by NESPAK and Master Plan Consultants, consolidated sample layout of MP-Plan under WSIP is attached at Annexure-D.

\textsuperscript{13} According to comments provided on draft report, Sindh Government has an Indus River Commission with mandate to inspect river embankments and take remedial measures.
• The Right Bank Out Fall Drain (RBOD) must also be completed and commissioned in time, so that salinity and contamination levels of Manchar lake may neutralize and the livelihood may restore.

3.7 Improving Agricultural Productivity

3.7.1 Challenge:

Sindh achieved a sustained growth of over 4% per year in the past three decades (1970-2000). This was made possible through the introduction of high-yielding varieties of wheat and rice in the late 1960s, combined with larger supplies of irrigation water and fertilizers. However, in the last decade (2001-2010), the pace of agricultural growth has slowed down to barely 3%.

3.7.2 Assessment:

Agriculture in Sindh simultaneously faces enormous challenges and great opportunities. The IBIS supporting agriculture in Sindh developed rapidly after 1932 and has been used beyond its intended capacity. With this water logging has become a regular feature on 30-45% of Sindh’s agricultural lands. Non-beneficial evapotranspiration is sky-high – close to 80%. This is a waste of water but also a cause for suppressed yields and high incidence of public health problems. Soil salinization in the irrigated areas has still increased from 49 to 54% of the irrigated land as measured in the two large soil salinity surveys of 1977-1979 and 2001-2003. The most important measure of all— the productivity of agriculture measured in terms of total productivity or productivity per unit of water, land, and other inputs– remains low by global and even regional standards. Water productivity in Sindh ranges between 0.32 kg - 1.14 of product per 1 cubic meter of water, which is 50-100% below figures elsewhere in the mega-systems of the region.

Apart from water management, there are important deficiencies in the agricultural support sector. There is insufficient access to quality inputs and a preponderance of mass agriculture. The opportunities to serve high value markets in the country and in the Middle East Region are not used, in spite of Sindh’s geographical position. The capacity for climate controlled storage, throughout the Province and at provincial airport is far too small.

3.7.3 Improvement Opportunities:

On the positive side, IBIS is a well-designed robust irrigation system that has the potential of supplying high-quality canal water at the right times and in right quantities, which is necessary for an increased land and water productivity. There is a large potential for increasing agricultural productivity (crop yield per unit of land and per unit of water) throughout Pakistan including Sindh. This is evident if we consider the data in Table-7, referred by the Food Security Task Force (2009) and Sindh Agricultural Statistics, showing the yield differences between the national and provincial averages and what some progressive farmers are able to achieve. The analysis points out several other factors (quality seeds, balance fertilizer use and post-harvest system) must be addressed collectively to improve crop productivity.
Table-6: Yield Gap for Major Crops (tons/ha)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Progressive Farmers</th>
<th>National Average</th>
<th>Yield Difference (%)</th>
<th>Sindh Province Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>4.6</td>
<td>2.6</td>
<td>44</td>
<td>2.3</td>
</tr>
<tr>
<td>Cotton</td>
<td>2.6</td>
<td>1.8</td>
<td>31</td>
<td>0.6</td>
</tr>
<tr>
<td>Rice</td>
<td>3.8</td>
<td>2.1</td>
<td>45</td>
<td>2.7</td>
</tr>
<tr>
<td>Maize</td>
<td>6.9</td>
<td>2.9</td>
<td>58</td>
<td></td>
</tr>
</tbody>
</table>


Adoption to issues of climate change, water scarcity can be a major step for sustaining livelihood of local people. The crop wise cultivated area assessment of Badin and Thatta Districts have adopted crops with less water requirements. The Box 11 and 12, present graphs from Master Plan Consultants for Left Bank of River Indus and Delta Zone report, through Statistics of Agriculture Department, GoSindh. The period crop data is from 1991 up to 2010. It is clearly evident that cultivated area has increased with introduction of drought resistant crops and these both districts are getting lower supplies against their designed share.

Box 11: Badin District Crop Wise Cultivated Area (1991-2010)

Box 12: Thatta District Crop Wise Cultivated Area (1991 – 2010)
3.8 Building Knowledge Base and Improving Human Resources Capabilities

3.8.1 Challenge:

In spite of the importance of water in Sindh’s economy and politics, water management in Sindh has not kept pace with the rest of the world. There is limited debate on water management options in addition to missing links between research, education, and the operations of water agencies. Basic water data collection is limited, in some cases suspended, and in other cases marginalized. If any of the action areas highlighted by this study is to bear fruit, it has to be sustained by a different culture for managing water and the operation of water facilities. Services should be managed on the basis of measured performance and by using knowledge of engineering, water law, the environment, economics, and other relevant disciplines.

3.8.2 Assessment:

Access to water information and knowledge networking are key factors in effective water resource management. The major problem in Sindh, and Pakistan, does not stem solely from a shortage of resources. Though the level of hands-on capability of the irrigation managers is high as is the team spirit and the ability to operate in often-difficult circumstances, the water sector is affected by insufficient trained experts, and a lack of links between the public and private sectors causing a serious threat to water resources as well as serious environmental degradation. A number of separate standard operating rules and guidelines exist for managing storage, releases for irrigation and hydropower generation; however, no comprehensive multi-functional decision support models or asset management systems currently exist. This needs to be addressed as part of a system overhaul.

3.8.3 Improvement Directions:

i. Start mapping and monitoring surface water quality through GIS Gadgets, so as to come to grips with the control of effluent disposal and the impact of (drinking) water quality.

ii. Support and expedite the River Simulation Model (All Pakistan basis; responsible agencies IRSA and WAPDA): An Indus River simulation model (or a computer-aided river management system) can help manage water resources in a more effective and efficient manner by relating changes in climate, land use and/or water distribution to the sustainability of water allocation, economic production, and/or ecosystem health. WAPDA is currently working on such computer modeling.

iii. Develop a Canal Management Decision Support System (responsible agencies: SIDA and ID). The system will assist canal automation with limited technology and more human interaction. The objectives are:
   ▪ Investigate a range of options for measuring, monitoring, and controlling water flows and use
   ▪ Improve predictions for demand for irrigation, and reduce transmission losses
   ▪ Improve flow management based on real-time flow measurements.

iv. Develop an Asset Management System (responsible agencies ID and SIDA): Strategic asset management is the planned alignment of assets to achieve the best possible match with agency service delivery strategies.

v. Build a Knowledge Base for Groundwater Management (All Pakistan basis; responsible agencies Ministry of Water and Power, WAPDA, PIDAs, IDs). The knowledge base should focus on developing an understanding of the potential and a mechanism for concurrent management of groundwater in the Indus system looking at groundwater flows, salinity, and groundwater movement.
4. The Irrigation Management Strategy for Irrigated Agriculture of Sindh (Pakistan)

An overhaul of the irrigation system is overdue. This will consist of a reassessment of the water distribution arrangements and the current infrastructure, looking at the capacity of the canal and barrages to deal with realistic peak floods, providing for the different functions, improve water management and, cutting back the outside interference that has crept in the system, as witnessed by the proliferation of direct outlets and uncontrolled effluent disposal. There is a need to restore order in the management: more flexible operations in the deployment of essential field staff, higher professionalism and secure financing.

4.1 Reference Framework

This strategy concerns the future of irrigated agriculture in Sindh and the services that the irrigation sector will provide in the next 15 years. It is believed that the agriculture future of Sindh is bright, if it can build on three potentials: Sindh strategic location in one of the world’s most dynamic regions; the unused potential to make most of the water resources allocated to Sindh and its young and abundant human resources.

The productive use of irrigation water requires well-secured infrastructure and well developed human resources in the form of knowledge and institutions. Investments in institutions, infrastructure, and information are necessary, and must be examined together while formulating irrigation water development and management strategies. Institutions include the rules and organizations that govern water allocation and use. To address the identified issues, we propose that the Sindh Government undertake strategic initiatives for achieving its development goals related to irrigated agriculture. We believe such province-wide initiatives are best done through broad, well-informed stakeholder participation and finalized in a collaborative way with all stakeholders. Towards this objective, the team held four consultative workshops with government officials, water users and other stakeholders. Key topics discussed in these workshops and lists of participants are provided as Appendix A.

4.2 Strategic Initiatives, Activities & Directions

As sustainable water resource management moves to the forefront of national and provincial policy, it is critical to have the institutional framework, infrastructure and information necessary for good decision-making. The current institutional framework is not adequate to support good irrigation water management, and information needed to support decision-making is not readily available. The irrigation canal network and related infrastructure are deteriorated and so is the quality of land and water resources. In summary, the three building blocks of good resource management – institutions, infrastructure and information – are deficient in the province’s governance of water for irrigated
agriculture. The team recommends strengthening these three elements of good irrigation sector management.

A number of initiatives are to be pursued required achieving the vision of the irrigation sector serving a prosperous Sindh in the coming fifteen years. These are:

i. Set Water Resource Management in Place
ii. Manage the Essential Irrigation Assets/ Protecting Resource Base
iii. Institutional Right-Setting
iv. Get the Financing System Right
v. Enhance Human Resource Capacity
vi. Have Management Based on Information/ Building Knowledge Base
vii. Develop Water Resources Outside IBIS
viii. Vitalize Agriculture

4.2.1 Strategic initiative 1: Set Water Resources Management in Place

As sustainable water resource management moves to the forefront of national and provincial policy, the current institutional framework is not adequate to support good irrigation water management, and information needed to support decision-making is not readily available. The irrigation canal network and related infrastructure are deteriorated and so is the quality of land and water resources. In summary, the three building blocks of good resource management i.e. institutions, infrastructure and information – are found deficient in the province’s governance of water for irrigated agriculture. The team recommends strengthening these three elements of good irrigation sector management.

To meet with the current multiple demands for water services, water resource management in Sindh will need to be substantially improved. The management of the irrigation system in Sindh plays a vital role in water resource management and in fulfilling a large number of functions.

There is considerable scope in Sindh to manage water resources better and herein lays also the potential for future growth. A telling episode was the period of 1998-2003 when due to drought the amount of water in Sindh was less, yet yields in a number of areas increased. In some area this was the effect of the commissioning of works under the Left Bank Outfall Drain, but in other areas there was a better balance between water supplied and used. There is hence scope in several canal commands to reconsider water allocations and additional diversions and come to conjunctive management whereby surface and groundwater use are balanced. Especially in area with good quality groundwater (30% of deeper groundwater; 44% of very shallow ground water) of the area, there is scope to balance surface water and groundwater supply and use. This optimized conjunctive management would free up water for use elsewhere. The importance of groundwater needs to acknowledged and were possible stimulated and regulated

The second major challenge in water resources management in Sindh is the safeguarding of water quality. The canal and drainage network cross through cities and industrial areas: they are used for urban and industrial water supply, but also receive the untreated effluent. The public health implications – for humans and livestock – are severe. If Sindh is to develop, this issue has to be
addressed by enforcing legislation and by guiding industries and municipalities to treat waste and reuse of wastewater.

4.2.2 Strategic direction 2: Manage the Vital Assets/ Protecting Resource Base (Floods & Droughts).

Irrigation services are essential to Sindh and the infrastructure barrages, canals, embankments, cross regulators and drains are key assets for all. The irrigation infrastructure is however partly out-dated and partly has been placed under tremendous pressure to support ever-increasing crop intensities and other multiple functions. A system overhaul is overdue that looks at the current water distribution (see above) and also at the infrastructure as it stands. It is important to see where the priorities are for improvement and adjustment to changed climate conditions and make a plan to replace aged and no longer functional systems on a priority basis.

Climate change and overall changes in the hydrology that are coming with it are the important background against which the capacity of the systems and ability to deal with floods should be looked at. There are four elements: the capacity of the barrages and embankments to deal with floods; the need to create more storage within the water system; the need for investment in drainage to deal with storm water and the special attention for the coastal zone.

Sindh has witnessed in the last five-year three major flood events. These have put the infrastructure to test and issued a strong warning signal. There is a need to review the conditions of the barrages in Sindh and the flood embankments and see whether they can ensure long-term security. This has already been completed for Guddu Barrage, and a similar assessment needs is under completion for the Sukkur barrage. The conditions of the embankment needs to be assessed in a modern, scientific manner and in the long run a system of third party inspection of the flood management infrastructure may need to be in place to ensure that it receive the constant vigilance that is required. Modern dike surveillance technology needs to be introduced to do justice to the importance of more than 2000-kilometer of prime embankments and additional embankments along canals and drains.

Related to the larger incidence of high peak discharges interspersed with droughts, as is the long-term scenario for the Indus Basin Irrigation System there is a need to create more storage throughout the Indus Basin. The same is true for Sindh. There are several options and this has to be systematically explored:

- Storage in lakes and depression in the flood plains
- Making better use of the existing reservoirs (Manchar Lake) and linking their management to the Indus river: this has been done for Keenjhar and Chotiari Reservoir
- Overflow structures from the Spinal Drain to reservoir and recharge areas in the adjacent desert country
- Field level water storage – creating storage ponds in water insecure areas

Following the overhaul study special attention is required for strategic investment in drainage. The same was also assessed as part of the Master Plan for Left Bank of Indus and Delta Zone, recently completed under WSIP. It is prioritized as reopening of blocked natural drains and selective
investment in the rehabilitation of new drainage works. The priority is to develop the most essential works. It is important to control excess irrigation in areas prior to investing in drainage and also avoid developing systems, which may be too costly and cumbersome to maintain and operate.

Finally, the coastal zone of Sindh is one of the most deprived and vulnerable areas in the world. Seawater intrusion is affecting an ever-larger part of the area – triggered by sea level rise and subsidence of the delta land. The hydrology of the area has also been severely changed by the works undertaken under the Left Bank Outfall Drain, including some of the failures. Flood protection and flap gate outlets in the drainage canals are a high priority to safeguard the land and create a clear barrier between land and seascape. Special measures – agronomic, fishery – can bring productivity to these areas and provide the livelihood of the marginalized population living there.

**Box 13: The Master Plan Phase-III study on Sea Water Intrusion:**

![Image](image_url)

**Ghyben-Herzberg Theory for Sea Water Intrusion and its Remedies**

In general, given the stakes with the irrigation system there is a need to modernize and introduce state of the art techniques in the management of the Sindh irrigation system. There are many techniques that would make a considerable difference in the quality of the service and reduce costs of operation but that are not applied: bathymetric surveys and suspended solid samplers to manage the sedimentation near barrages; radial gates on main canals for efficient operation, floatable booms to remove trash in front of barrages and cross-regulator, the systematic use of cattle ramps to avoid canal damage and sedimentation. Innovative techniques are real time dredging where by sediment is carried by the speed of water or the use of composite gates to ease the use of operation. A spirit of modernization should be created.

4.2.3 **Strategic direction 3: Reform Institutional Framework**

The pressures on irrigation institutions are well known: financial, performance-wise, the ability to innovate, the overall governance and engagement of stakeholders. They caused Sindh to take the lead in Institutional Reform in the irrigation sector from 1997 onwards. The reforms had a number of tenets: a larger autonomy for the irrigation organization so as to create a better professional environment; supervision by boards of professionals and stakeholders; the ability to raise
Irrigation Management Strategy for Irrigated Agriculture of Sindh Province (Pakistan)

direct finance for the irrigation services and a larger complementary role of water users, particularly in the shape of Farmer Organizations (FOs).

More than fifteen years down the line the points of departure of the reforms are still valid. The implementation of the reforms however has been partial and has not delivered upon all expectations. It has been moreover for part of the period been affected by traditional monopolies, resistance and controversy.

It is time to take stock and learn from both the achievements and the failures. FOs and WUAs are well known institutions by now in rural Sindh, and these need to be maintained and strengthened. Some were created in a hurry without much local ownership, whereas others had a more solid base. What is important is however not so much that they are created but how they continue to function and support each other. In many agricultural economies farmer organizations have been the driving force for agricultural change, providing services, selling products, undertaking lobby and even doing research and promoting innovation. Sindh equally has examples of powerful farmer interest groups. The next step is not have the FOs wither away but to make them part of the agricultural service delivery and permanent water governance in Sindh. This requires the nurturing of local leadership and providing opportunities in agricultural development beyond the operation and maintenance of the distributaries and minors. It also requires more seriousness in enforcing the terms of cooperation: systematically having FOs re-registering and applying sanctions in case of non-collection of water fees or other duties. The FOs should be considered as part of the system of water governance not as voluntary civil organizations. In the original plan the AWB would be driven by FOs: the mutual accountability of AWBs and FOs needs to be reinforced to ensure the discipline and professionalism that is required for any strong irrigation sector.

The points of departure of AWB – the ability to fairly remunerate the high professional skills required in irrigation and the creating mechanism to move out of the deadlock of underfinancing and underperformance also still apply. It is important to take stock of the basic achievement of the AWB that exist in service delivery and in controlling misuse and take lessons out of this for their operations, i.e. the engagement of staff from the market and the functioning and composition of their supervisory boards. This assessment should help to remedy shortcoming but also to see how elements of the reforms can be integrated in the entire irrigation sector in Sindh, in particular the larger financial autonomy, the better remuneration packages, the supervision and performance enhancement mechanisms and the mutual responsibilities of irrigation provider and FOs. The option of AWB operating as canal companies should be considered too. It is important to restore the unity and come to a single strong and present day irrigation sector in Sindh. A high-level review committee is to be constituted at short notice with this agenda. A constant complaint has been the political interference of the irrigation operations and organization by non-professional politically well-placed persons. If the irrigation sector is to become the backbone of a prosperous Sindh this has to be severely constrained. The system of posting has to be on professional basis and the lower formation need to go back to work charge arrangements. There should be a total ban on direct outlets and any modification to the system has to be seconded by professional judgment. There needs to be active support from judiciary and local authorities in addressing well-documented cases of system encroachments. The successful example of developed countries can be used as benchmark e.g Box 14.
Box 14: Water Conservancy Districts in Western United States

The Middle Rio Grande Conservancy District operates, maintains and manages irrigation, drainage, and river flood control in the Middle Rio Grande Valley in New Mexico. It promotes efficient and responsible water management protects the environment, wildlife and endangered species in cooperation with other local, state and federal agencies. MRGCD, like many other water districts in Western U.S, are “special agencies” instituted under state law to deal with matters related to water only. Administratively, the District is governed by a Board of Directors (seven in number) who are elected from the water users within the District service area. The Board sets policy and institutes rules and regulations related to the district operations. The actual day-to-day operations including water delivery, distribution among all users and the system O&M is supervised by a Chief Engineer who is appointed by the Board. The chief engineer is a professional engineer who is paid for his services, whereas the Board members serve on a voluntary basis. The Chief engineer has a large number of technical and administrative staff located at the main MRGCD office in Albuquerque and plus additional field staff located near the four main water diversion points.

At the time of the Conservatory’s creation in 1923, the flow of the Rio Grande through central New Mexico fluctuated dangerously and unpredictably. The shallow water table throughout the valley turned over 60,000 acres of farmland into swamps or salt grass fields. Frequent floods often destroyed entire villages; one scoured a path right through what is now major city of Albuquerque. Also, the existing irrigation systems were insufficient and primitive; many were hundreds years old and desperately needed rehabilitation. The MRGCD was created to provide flood protection from the Rio Grande, drain swamplands and provide irrigation water to farmlands. By 1935, the Conservancy District had built the storage dam at El Vado and the diversion weirs at Cochiti, Angostura, Isleta, and San Acacia to manage its water, and several hundred miles of new irrigation and drainage canals. Nearly 200 miles of riverside levees and a system of jetties and checks alongside the river protected against floods. The drains funneled water away, lowered the water table, dried the land and reclaimed it for agriculture. The Army Corps of Engineers spent another $40 million on flood control reservoirs and levees, including the construction of a new dam at Cochiti that created the present-day Cochiti Reservoir at the upstream end of the irrigation system.

4.2.4 Strategic Direction 4: Get the Financing System Right

It is important to adequately finance of all dimension of the irrigation strategy. Adequate irrigation financing would put water policy and strategy on a sustainable financial path.

The irrigation system has suffered from a low level of funding. Finances have been made available for basic maintenance but over the years this has been typically below the norms. Major investment and rehabilitation is paid for from international loans. On the income side the water related abiana collection is below expectation too: rates for this water tax are low compared to international standards and collection efficiency is falling and is in the order of 30-40%

Under the Sindh Irrigation Reforms a bold effort was made to break the deadlock. The Farmer Organizations were enabled to collect the abiana, keep 60% of the proceedings and pass on the balance to the Area Water Boards to pay for funding. Collection efficiencies were satisfactory at the early stage but then dropped too low levels. All this performance is disappointing compared to some historical facts. The Sukkur Barrage was constructed in 1932 the investments were recouped in seven years from the abiana. Until the early 1970s abiana collection was close to hundred percent but after that decline set in.

We live in a different era but the value of irrigation water is undiminished and there is no reason why paying for water services should be abysmal. It requires the trust and vision of the main stakeholders, farmers, their representative bodies and the government authorities, to turn the picture around. As part of the irrigation strategy, healthy financing is essential and three directions are
proposed. The first is to simplify the system of collection and also make use of 21st Century technology. Rather than relying on the outdated and corruption-prone systems of field assessment, a gradual transition should be made to a system where irrigation service charges are associated with the land that is irrigated and the water allocation fixed on the basis of the irrigation allocation. This will make it far easier to collect due amounts and give farmers a clear right to an equal amount of water. If water is not provided a check with the help of remote sensing technology would set the picture right and decide whether compensation would be justified.

The second change is in close consultation of all major stakeholders to adjust the water charges that at present are so low that it is unattractive to collect them. This requires however the confidence of many stakeholders that positive changes are happening.

The third change is to make serious work of other revenues than abiana. The irrigation system provides many services with a significant economic and social value. The irrigation system is the main source water for urban areas. Karachi for instance receives 1200 cusecs on a daily basis. Yet no commensurate payment is made for this. An overview Municipal & Industrial Water Supply, Pricing and Billing under different sections is given in Table-8:

### Table-8: Water Availability for Karachi:

<table>
<thead>
<tr>
<th>S#</th>
<th>Source</th>
<th>Supply (Million Gallon / Day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Indus River</td>
<td>550</td>
</tr>
<tr>
<td>2</td>
<td>Hub Dam</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>Total</td>
<td>650</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S#</th>
<th>Source</th>
<th>Supply (Billion Gallons Per Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Annual Intake from Indus River</td>
<td>201</td>
</tr>
<tr>
<td>2</td>
<td>Seepage Losses due to low conveyance efficiency 10% (Due to KB Feeder Earthen Nature and Storage at Keenjhar Lake)</td>
<td>-21</td>
</tr>
<tr>
<td></td>
<td>Net Annual Supply from Indus River</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>Net Annual Supply from Hub Dam</td>
<td>33</td>
</tr>
<tr>
<td>3</td>
<td>Total</td>
<td>213</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S#</th>
<th>Source</th>
<th>Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Approximate Municipal Use by 20 Million People</td>
<td>170</td>
</tr>
<tr>
<td>2</td>
<td>Approximate Municipal Use 20% of Total</td>
<td>43</td>
</tr>
<tr>
<td>3</td>
<td>Total</td>
<td>213</td>
</tr>
</tbody>
</table>
Table 9: Current Water Rate Statistics of Karachi & Different Cities in Sindh:

<table>
<thead>
<tr>
<th>S#</th>
<th>Kind of Supply</th>
<th>Rate Per 1000 Gallon (PKR)</th>
<th>Rate Per 1 Gallon (PKR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bulk Water Supply, Karachi</td>
<td>170</td>
<td>0.17</td>
</tr>
<tr>
<td>2</td>
<td>Industrial Water Supply, Karachi</td>
<td>212</td>
<td>0.21</td>
</tr>
<tr>
<td>3</td>
<td>Industrial Water Supply, Nooriabad</td>
<td>150</td>
<td>0.15</td>
</tr>
<tr>
<td>4</td>
<td>Industrial Water Supply, Sukkur</td>
<td>75</td>
<td>0.7</td>
</tr>
<tr>
<td>5</td>
<td>Tanker Supply, Private</td>
<td>2,000–7,000</td>
<td>2–7</td>
</tr>
<tr>
<td>6</td>
<td>Bottled Water, Nestle, Aquafina etc.</td>
<td>100,000–200,000</td>
<td>100–200</td>
</tr>
</tbody>
</table>

Irrigation Department Notified 1999

<table>
<thead>
<tr>
<th></th>
<th>Municipal Use</th>
<th>Industrial Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Possible Revenue at 1999 Rates</td>
<td>85 Million PKR</td>
<td>43 Million PKR</td>
</tr>
</tbody>
</table>

Current Billing

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Recovery</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

Likely Subsidy / Grants / Bailouts by GoSindh Annual Basis

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6 – 8 Billion PKR</td>
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Proposed Tariff

<table>
<thead>
<tr>
<th></th>
<th>Estimated Recovery Per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PKR. 430 Million</td>
</tr>
<tr>
<td>2</td>
<td>PKR. 850 Million</td>
</tr>
<tr>
<td>Total Income</td>
<td>PKR. 1,280 Million</td>
</tr>
<tr>
<td>3</td>
<td>PKR. 720 Million</td>
</tr>
<tr>
<td>Estimated Income from Rest of Sindh</td>
<td>PKR. 2000 Million¹⁴</td>
</tr>
<tr>
<td>Total Recovery</td>
<td>PKR. 2000 Million¹⁴</td>
</tr>
</tbody>
</table>

Source: Paper Presentation by Mr. Fazlullah Qureshi, Ex-Additional Chief Secretary (Dev.) GoSindh, at Seminar on Irrigation Water Management, Issues & Options, 23rd August, 2014. Karachi

Other examples of making better use of the multiple functions are: the use of canal banks for commercial forestry, fisheries, the use of roads, the development of water front property and the exploitation of leisure opportunities. All these could generate considerable income to pay for the irrigation and drainage system. Beyond the income for the irrigation and drainage services the additional structured activities would yield virtuous jobs as well, much needed in the Pakistan’s economy.

4.2.5 Strategic Activity 5: Enhance Human Resources Capacity

The management of the irrigation system is a highly skilled discipline. It is an almost ‘art’ like profession – particularly, in dealing with flood and drought emergencies in the absence of essential facilities. A well-informed Sindh irrigation sector management needs to have well educated human resource, which is provided with means to gather data and information and then use this information in making correct decisions. There is a need for capacity building and strengthening the professional cadre in the irrigation sector.

¹⁴ The Average O&M and Establishment Expenditures of Irrigation Department are PKR. 2161 Million. (Irrigation Water Pricing and Its Sustainability by Dr. Allah Bux Sufi).
This important initiative would include following action items.

- Strengthen monitoring of water quantity and quality in irrigation systems, both for surface and ground water.
- Enhance quality of education in the province and in country
- Provide on-the-job trainings
- Provide better salary and other incentives to attract and retain good quality staff
- Provide supporting facilities for improved job performance including incentives, instrumentation, computers and vehicles for transportation.

There is very little monitoring of water quality and quantity in Sindh. Water quantities are monitored in the Indus at barrages and at intakes to main canals. Downstream of the main canal (branch/distributary canals), the canal system is operated by monitoring water levels. There are very little data and information generated, and the information does not transmit to actions to improve management. Management actions are taken largely on an ad hoc basis, in response to a crisis or emergency.

The capacity to manage information in support of decision-making is also underdeveloped. Information describing groundwater availability and quality also is inadequate. No integration is established with information on land quality, issues of land degradation, and human impacts on land and water resources. The quality of applied scientific research is low and needs to be enhanced. Participation of specialists in international scientific conferences is largely not funded. This factor and the specialists’ limitations in modern foreign languages challenge the application of analytical research methods. Funding for scientific research should be increased, to improve the quality of monitoring for water quality and quantity.

The important element is to build up a stronger professional capability. At present much of the learning is from peer-to-peer. To strengthen this, a stronger internal training capacity may be developed, with the reactivation of the Irrigation Academy. This will systematically upgrade skills through short-term training and make it possible to develop linkages with national and international knowledge providers and research organizations. As Sindh’s irrigation systems is one of the largest irrigation systems globally – with the Rohri Canal and Nara Canal probably the canal serving the largest command area in the world – there is a strong case for having a dedicated training facility, that will also help introduce the various institutional and technical innovation planned over the next fifteen years as part of this strategy, for irrigation staff as well as leaders of Farmer Organizations.

4.2.6 Strategic Activity 6: Have Management Based on Information/ Building Knowledge Base:

At present even basic information on water quantity and quality in irrigation systems, both for surface and ground water, is not available. Overall in fact the situation data availability in the past was better, in spite of the fact that these days measurement and data transmission techniques are sophisticated and low cost. As a result much of the canal operation is based on experience, whereas there would be a case to move to a higher level of management, including the management of water resources and particularly the control of waterlogging and salinity. Clearly this will need to change. Water quantities at present are monitored in the Indus at barrages and at intakes to main canals. Downstream of the main canal (branch/distributary canals), the canal system is operated by
monitoring canal water levels. Groundwater level data also need to be monitored systematically, restoring the SMO system but using automatic data transmitters. Another area for data collection is the use of satellite images as collected by SUPARCO to be included measurement of water productivity with sufficient resolution to assess performance of the irrigation systems, the area with oversupply and shortage and the extent of water logging and salinity.

There are very little data and information generated, and the information does not transmit to actions to improve management. Targets on water productivity should be set for each part of the systems and should be open for discussion.

Data are also needed on water quality, especially the extent of contamination from industries and cities. Management actions are taken largely on an ad hoc basis, in response to a crisis or emergency. The capacity to manage information in support of decision-making is also underdeveloped. Information describing groundwater availability and quality also is inadequate. No integration is established with information on land quality, issues of land degradation, and human impacts on land and water resources. The quality of applied scientific research is low and needs to be enhanced and be part of regular review of improving system performance.

4.2.7 Strategic Direction 7: Develop New Irrigation Infrastructure in Areas outside IBIS:

The emphasis in irrigation in Sindh has been on the Indus Basin irrigation system: this is the major production basket with much unused potential. There is however also important scope outside the Indus Basin in Sindh and this would serve some of the more dis-privileged communities in the Province as well as creating special product niches. One promising area is the development of various small/medium size structures in the hilly catchments in Sindh: small dams, sand dams, subsurface dams or a host of other recharge and retention structures in the upper watershed or improved appropriate spate irrigation at the foothills. There is a large range of options to be utilized in these environments, some successful elsewhere but hardly tried in Pakistan. This development options can be very beneficial especially when coupled with the use of high-efficiency water application systems (drip irrigation) and other related inputs. The objective must be to diversify income through integration of watershed, reservoir and command area. Watershed area can be used for production of fuel wood and grasses, reservoir for freshwater aquaculture and command area for high-value agriculture. This model has the potential to increase the productivity and production by many folds and provide opportunities for un-employed rural youth. The techniques used depend on the rainfall patterns, prevailing livelihoods – between Tharparkar and Kirthar there is a range of options to be used that are locally appropriate.

A second important non-IBIS option is to manage the flood plain areas. There are several reasons to do so. First is to create more storage in the flood plains, so as to secure the availability of water off-season and in dry years. The flood plains have been the scene of a rapid conversion in the last three decades: from areas that were covered with shrubs and forest, they have become prime agricultural land. There is a need however to regularize the use of the flood plains: the land encroachment in the flood plain has contributed to increase flood risks: they have narrowed the natural river course and they have narrowed the flood risks and exposure of land users.
4.2.8 Strategic Direction 8: Vitalize agriculture and improve productivity

Finally, there have been dramatic changes within the irrigated agriculture in Sindh. A main change has been the introduction of new crops – rice and sugarcane in Left Bank, and sunflower in Badin. This stands for the dynamism in the farming, though unfortunately some of these changes have had a negative effect on water management – creating water logging upstream and curtailing water supplies downstream.

Improving agricultural productivity and vitalizing the agricultural sector in Sindh is an objective that stand on its own but is also a necessary ingredient of the irrigation sector strategy.

As part of the overhaul of the entire irrigation systems there is a need to reconsider and promote the best fit cropping patterns for the different part of the command area, taking into account soil and surface salinity, and groundwater availability. Within the cropping patterns there is a need to increase productivity. The current average yields of major crops in Sindh are almost half of the achievable potential of high yielding crop varieties. Narrowing down this ‘yield gap’ is possible if we can correctly combine the balanced use of fertilizers, proper and timely use of water, and the use of quality seeds and saplings. The improvement of agricultural productivity is the main complement to the irrigation sector improvement.

There is also a need to encourage diversity and innovation – particularly to cater for the urban markets and demand for fresh food in Pakistan and the entire Middle East region. There are encouraging examples of innovative farming practices in Sindh – and better crop husbandry (mango pruning, mulching) that create better quality products – cheko, plums, strawberries, but the examples need to increase in scale and size.

This will also need stimulating and improving the services in the private sector that at the moment is still quite fragmented and limited in size. Important private sector services include the provision of climate-controlled storage and the widespread availability of inputs of high quality.

A distinct feature in Sindh is the salinity of groundwater and soils – this may be seen not merely as an obstacle but as an opportunity too. There is much more scope for bio-saline agriculture than currently applied in Sindh. There are important opportunities in applying special salt tolerant crops and introducing brackish aquaculture. But there are many more opportunities: salt tolerant varieties of common crops (rice, wheat, and potatoes), special soil agents and the systematic application of appropriate agronomic measures. At present these are not common in Sindh, even in areas with significant salinity or sodicity problems. These can be introduced and would contribute to the considerable untapped potential for agricultural development in Sindh.

Extension services are a weak link. Here modern media can overcome the gap – new ways of reaching farmers through text message and smart phones should be developed. A 24/7 agricultural television services as in Turkey should be introduced in Sindh, serving to communicate through attractive programs good practice and agricultural innovation and also providing an outlet for the agricultural service industry to familiarize farmers with their output. There is a need for a complete transition. Much can be learned from neighboring countries, where agriculture is one of the fastest growing sectors.
In general, as mentioned by the Task Force on Food Security (2009), water has emerged as a fundamental constraint to agricultural growth – “Inefficient use of water is one of the major issues confronting crop productivity”. This is absolutely true for Sindh where water logging and seasonal shortage exist alongside each-other and precision land-leveling, substitution of high water consuming crops with low water consuming crops, promotion of water saving technologies such as drip and sprinkler irrigation and greenhouses is still in infancy. There is a need for continued investment in on-farm water management. In addition to the watercourse lining and precision land leveling, the program should promote more efficient ways of water application to land. The technology of drip irrigation has advanced and is available at much less cost compared to some years ago. The use of decision-support systems to assist in irrigation scheduling should be introduced to progressive farmers. In the long run, the On-Farm Water Management Program can be graduated to an Irrigation Advisory Service, which can act as an extension service specializing in irrigation water management. Such an irrigation advisory service can engage in applied research related to soil-water-plant relationships and extend new knowledge to farmers. A case in point would be the SRI system of rice cultivation, which can replace the current high water consuming (Puncho) method. Irrigation is to move to precision irrigation, not only to save water and use it elsewhere, but also to support higher production levels.
4.3 Strategy Implementation

4.3.1 Transparent operations

An effective and transparent method of implementing Sindh’s irrigation strategy is crucial to ensuring long-term protection and conservation of water resources. The development of this implementation framework will be a participatory process that considers both present and future demands on water, and ensures the protection of ecosystems. Supporting legislation must provide appropriate roles and responsibilities for regulation and management of the irrigation sector, in a way that meets internationally accepted norms to allow appropriate cooperation in irrigation system development and management.

4.3.2 (a) Financing

It is important to analyze and strengthen the economic dimension of the irrigation strategy. A comprehensive analysis would involve following considerations:

Make the strategy financially robust, in order for it to contribute to economic development

- Put water policy and strategy on a sustainable financial path
- Reform economic instruments for improved irrigation water management
- Make the link between water policies and economic development.

The first step in achieving a robust strategy is to inventory the economic instruments available to policy makers. The focus on economic instruments is necessary because they:

- Help generate revenues to finance water services
- Promote water efficient practices
- Make water efficient technologies competitive
- Make low cost options attractive, and
- Value the benefit of watershed services.

Some commonly used forms of economic instruments are:

- Abstraction charges or fees and pollution charges
- Tariffs for water services
- Water-harmful subsidies
- Payment for ecosystem services.

4.3.2 (b) Water pricing:

Economists often promote pricing as the best mechanism for communicating scarcity conditions. Indeed, in the case of many resources and commodities, low prices can connote relative abundance, while higher prices reflect increasing scarcity. It is frequently asserted – especially by development agencies – that the solution is to increase tariffs to recover costs (capital and/or operation and maintenance). Successful experiences show that the process cannot start with increased tariffs, since customers reasonably will resist paying more for a poor quality, unaccountable...
service from an institution which is not accountable to them. The process must begin with a focus on service (Figure 11). Farmers will be more agreeable to paying an appropriate price for irrigation water, when the service they receive is reliable, timely, and affordable.

**Figure 11: Irrigation Service Fees as a Function of Service Quality**

![Transition from low-level to high-level equilibrium](image)

4.3.3 Performance Monitoring of Strategy

A strategy is only as good as the leadership that implements it. The responsible organization will need to monitor the progress of its efforts related to issues such as water allocation, resource protection, and improvement of irrigation efficiency. Such assessments should not only be done internally, but in an open and transparent manner with latest Monitoring and Evaluation Tools, with the findings (positive and negative) widely publicized.

The Monitoring & Evaluation program will include water quantity, water quality, recording abstractions and license management, potable water availability and accessibility and other key indicators and parameters. The use of a Geographic Information System, Remote Sensing (GIS/RS) Tools integrated with Information Management System (MIS), will help to ensure that proper performance indicators for each program are established, measured and then analyzed to assess program performance.
5. **Sequencing of Strategic Priorities & Timelines**

The strategy applies for fifteen years. In this period the vision is of the irrigation sector supporting a vibrant farm economy in Sindh and to do justice to the many functions demanded from the irrigation system. The strategy will have to be applied in steps. Below the sequencing priorities of the strategy is shown in Table 10.

**Table 10:**

<table>
<thead>
<tr>
<th>Priorities</th>
<th>Short term (year 1-5)</th>
<th>Medium term (year 6-15)</th>
</tr>
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</table>
| **Set water resource management in place** | • Assess scope for conjunctive management.  
  • Enforcing of environmental legislation.  
  • Enforcing Ground Water Management Regulations.                                                                                                         | • Conjunctive water management in place  
  • Freed up water reused  
  • Productive waste/ waste water reuse                                                                                                                  |
| **Manage the vital assets**     | • Assessment of Sindh IBIS system overhaul.  
  • Conduct detailed survey of coastal area.  
  • Assessment of drainage priorities.  
  • Systematic assess storage options.  
  • Develop project for implementation.                                                                                                                       | • Selected priority investment.  
  • Coastal zone action plan implemented.  
  • Systematic surveillance of flood protection systems.  
  • Culture of technical excellence.                                                                                                                          |
| **Institutional right-setting** | • Rationalize staffing.  
  • Review of reform.  
  • Compact with provincial and local government and judiciary on protection of essential irrigation services.                                                                                       | • Introduce reform elements throughout irrigation systems  
  • New standards of professionalism and non-interference                                                                                                      |
| **Get the financing system right** | • Simplify abiana collection.  
  • Explore and set in place non-abiana revenue collection.                                                                                                 | • New business models.  
  • Fair water pricing – increased income.  
  • Fully developed charging for various irrigation system services (beyond abiana).                                                                               |
| **Enhance human resources capacity** | • Reactivate Irrigation Academy.  
  • Invest in professional development                                                                                                                         | • New cadres of irrigation professionals and new standards of operation.                                                                                     |
| **Have management based on information** | • Introduce flow measurement, monitoring irrigation deliveries and groundwater levels and water quality                                                                                                       | • System management based on real time information                                                                                                           |
| **Develop water resources outside IBIS** | • Start new methods of using non-IBIS systems.  
  • Conduct surveys.                                                                                                                                              | • Invest in non-IBIS systems.                                                                                                                                      |
| **Vitalize agriculture**         | • Develop media and IT based extension services.  
  • Compact with private sector for better farm services.                                                                                                      | • Scale up bio-saline agriculture.  
  • Private investment in storage and agricultural innovation and services.                                                                                     |
6. CONCLUSION

The IBIS is a well-designed robust system that has served its purpose well since it was built 150 years ago. Constrained by the technologies of the 19th century, it is a remarkable system that delivers and distributes water based on the laws of gravity and the clock. It also incorporated then state-of-the-art engineering, such as the design of “regime canals” that neither deposit silt nor scour their beds. However, it was primarily intended as insurance against famine and to support subsistence agriculture with a design annual cropping intensity of only 70%.

The current conditions are very different primarily because Pakistan’s population, and that of Sindh, has tripled in the last 60 years. The current cropping intensity in Sindh is close to 150 %, and more and more farmers are cultivating high water consuming crops including rice and sugarcane. Sindh irrigation sector now faces a situation of great uncertainty and risk because Sindh’s economy is effectively built on its single little-understood, massively-changed and vulnerable water system. To counter the risks to irrigation system, this study identifies, Priorities and their Timelines as detailed above at serial no 5.

Regions with far less water dependency and far simpler systems than Sindh have understood that securing their water assets requires large investments in infrastructure and the acquisition with application of knowledge. The government of Sindh needs to urgently make similar investments in modernizing and securing its irrigation infrastructure, and in the development and application of knowledge to better manage the conveyance system. Given its most-unique combination of complexity, vulnerability, risk and uncertainty, it is certain that the returns to such investments would be higher in Sindh than it is in these other places. The option of groundwater in Sindh is limited to very few areas as the groundwater is now increasingly turning saline due to over exploitation. The cost of diesel fuel is high and the electric supply very limited and unreliable. It is imperative that there be a new revolution in canal water and proper management control for ground water, so that farmers can have access to right quantities of irrigation water at the right time and at the right place. An improved level of performance and service in the canal system is the only environmentally sustainable way forward for irrigated agriculture in Sindh.

The demand for food will certainly continue to increase because of the population growth, and therefore more agricultural production is needed. Basic options for increasing food production are expansion of agricultural lands, or increased productivity per hectare. Expansion often means expansion into lands less suitable for agriculture. The government recognizes that upgrading and securing irrigation system and adopting better agricultural practices is the way forward to attaining food security in the province and the country. The strategies to cope with population growth and food insecurity must consist of securing the irrigation infrastructure, reforming irrigation institutions, research and development related to irrigated agriculture, agriculture extension activities, and diversification of agriculture by growing different types of crops on different land units.

The agricultural setting of the region can meet these challenges, especially with renewed emphasis on better management of the irrigation canal network, land and water resources. Proper irrigation water management should consider both demand side as well as supply side strategies. On the demand side, improvement of water use efficiency should have high priority for the irrigated agriculture sector. This could be accomplished through physical measures such as canal rehabilitation
and upgrading, construction of small storage reservoirs, and proper flow measuring and control-structures; or managerial measures such as water pricing. On the supply side, measures could be taken to effectively “increase” the amount of water available for irrigation and other societal needs. Universally practiced water conservation measures including water storage and rainfall water harvesting are simply not practiced in Sindh. Small storage reservoirs can be integrated in irrigation improvement programs to capture excess runoff, which would otherwise cause erosion, and make it available later for productive purposes. The capability to store water, even in small quantities, greatly helps water users in an irrigation system to effectively match their supply and demand and thereby reduce water losses. Similarly, harvesting of rainfall can also provide individual households with sufficient quantity of good quality water for domestic purposes.

The irrigation organizations including the government departments and water user organizations will play a central role for undertaking the above mentioned tasks. Towards this goal, the organizations will need to enhance their capabilities especially in the area of information collection and its use in decision-making involving water allocation and deliveries to various users, and ensuring the water resources are put to beneficial uses. It is important to complete implementation of the institutional reforms based on the 1997 Act and 2002 SWMO.

6.1 Way Forward

As noted by a wise observer of global development practice, what separates countries which are advancing and those which are not, is less the set of policies than it is the capacity to implement. The way forward to this strategy report should be to help break this deadlock – to help the Government of Sindh implement this strategy, and to get its development partners, too, to focus on action.

Section 4.3 of this strategy report outlines some general principles related to strategy implementation. The team did not have the time and resources to conduct an in-depth analysis as to how the Sindh Government would implement recommendations of this study. This is an involved and complicated task, which is location specific. The first logical task would be to share this strategy paper with all stakeholders, and build consensus as to what parts and recommendations need to be implemented and how best to implement the strategy recommendations. Such an exercise should lead to an Action Plan that would assign agency responsibilities for implementing agreed upon recommendations. It would also rank the strategy recommendations in terms of urgency and priority and assign a time line for implementing recommendations. With an Action Plan in place, the government will need to identify funding sources for financing the agreed upon actions.
7. REFERENCES

Agricultural Statistics of Pakistan, Year 2012-13
Pakistan Economic Survey: 2013-14
APPENDIX A:

Sindh Irrigation Management Strategy for Irrigated Agriculture
Workshop for Guddu & Sukkur Barrage Service Area


AGENDA

Session 1

Keynote Presentations

0900 – 0930  Registration
0930 – 0940  Recitation from Holy Quran
0940 – 0950  Welcome Address by Executive Engineer, Barrage
0950 – 1020  Formulation of Irrigation Strategy – Need, Objectives and the Process: Dr. Ramchand Oad, Professor, Colorado State University, Fort Collins Colorado U.S.A; and B.K. Lashari, Director, Water Resources Institute, Mehran University of Engineering and Technology, Jamshoro.
1020 – 1050  Key Note Speech on Issues and Opportunities/Solutions for Guddu Barrage Service Area:
1050 – 1130  Group Photo and Tea break

Session 2

Analysis and Discussions

1130 – 1200  Key issues and development opportunities related to infrastructure:
- Rehabilitation of main barrage, canal network, outlet structures for water supply to farmers.
- Water related hazards: flood management; soil and water quality (salt problem)
- Low productivity of water use in agriculture
- Lack of water storage (major dams and reservoirs)
1200 – 1245  Key issues and opportunities related to institutions: Irrigation Department, SIDA, Farmer organizations and WUAs
1245 – 1330  Key issues and opportunities related to management: performance monitoring of the irrigation system; farmer access to irrigation water: adequacy and equity; financing of development programs; financing of system O&M
1330 – 1400  Lunch and Prayer
1400 – 1530  Priority Strategic Initiatives
- Protecting the resource base: barrage and canal network; soil and water quality (salinity and water logging); flood management
- Reforming institutions: roles of Irrigation Department; SIDA and WUAs; Financing of development and rehabilitation programs; User fees for irrigation water
- Increase crop productivity in agriculture
- Increase human resource capabilities: generation of data and knowledge through regular monitoring; use of knowledge in decision-making
1530 – 1600  Tea Break and Prayer
1600 – 1630  Conclusion: summary of discussions and findings
1630 – 1700  Closing Remarks by Chief Engineer, Guddu Barrage.
Appendix-B

List of Participants in Irrigation Management Strategy Workshop for Guddu Barrage Team, held on 22nd December, 2014, at Park Inn Hotel, Sukkur

1) Irshad Ahmed Memon, Chief Engineer, Guddu Barrage.
2) Mr. Noor Muhammad Baloch, Veteran Irrigation Expert, Ex-Chief Engineer, Guddu Barrage.
3) Muhammad Ishaque Ahmed, Superintending Engineer, B.S Feeder, Guddu Barrage.
4) Ghulam Farooq Channar, Superintending Engineer, Sukkur.
5) Sultan Ahmed Mahar, Executive Engineer, B.S Feeder, Guddu Barrage.
6) Zareef Iqbal Khero, Executive Engineer, Sukkur Barrage.
7) Mr. Shahnawaz Bhutto, Executive Engineer, Ghotki Feeder Canal, Ghotki.
8) Ghulam Mustafa Sheikh, Executive Engineer, Executive Engineer, B.S Feeder, Jacobabad.
9) Mr. Habib Ursani, Deputy Head, PMO-SBRP, Irrigation Department.
10) Mr. Nasrullah Soomro, Deputy Director, PMO-SBRP, Irrigation Department.
11) Mr. Abdul Fateh Memon, Assistant Executive Engineer (Civil), Guddu Barrage.
12) Mr. Nazir Ahmed Shahani, Assistant Executive Engineer (Regulation), Guddu Barrage.
13) Mr. Abdul Ghaffar Sheikh, Assistant Executive Engineer, Qambar Sub-Division, Kashmore.
14) Mr. Ali Akbar Kalwar, Assistant Executive Engineer, Irrigation Department.
15) Mazhar Ali Bijarani, Assistant Executive Engineer, Irrigation Department.
16) Mr. Shah Muhammad, Assistant Executive Engineer, Sub-Division Kashmore.
17) Mr. Naseer Ahmed Sheikh, Irrigation Department.
18) Mr. Imdad Hussain, Assistant Executive Engineer, Irrigation.
19) Mr. Mohkamuddin, Assistant Executive Engineer, Kandhkot.
20) Mr. Khushi Muhammad, Assistant Executive Engineer, Irrigation Department.
21) Mr. Abdul Razzaque, Assistant Executive Engineer, Thul.
22) Mr. Abdul Razzaque Dahani, Irrigation Department.
23) Mr. Khursheed Khokhar, Assistant Executive Engineer, Thul, Kandhkot.
Appendix-C

List of Participants in Irrigation Management Strategy Workshop for Sukkur Barrage Team, held on 23rd December, 2014, at Park Inn Hotel, Sukkur

1) Mr. Ahmed Junaid Memon, Chief Engineer, Left Bank, Sukkur Barrage.
2) Mr. Anwar Ali Siyal, Director, Ghotki Feeder Canal Area Water Board.
3) Mr. Muhammad Rafique, Superintending Engineer, Khairpur East.
4) Mr. Amjad Dawich, Superintending Engineer, Irrigation Department.
5) Mr. Abid Hussain Naich, Executive Engineer, Ghotki.
6) Mr. Ayaz Ahmed Soomro, Executive Engineer, Ghotki.
7) Mr. Bahadur Khan, Executive Engineer West Division.
8) Mr. Zarif Khero, Executive Engineer, Sukkur Barrage.
9) Mr. Imtiaz Ahmed, Executive Engineer, Rohri Division
10) Mr. Ishaque Mahessar, Assistant Executive Engineer, Sukkur Barrage.
11) Mr. Mukhtiar Ahmed Dahri, Assistant Executive Engineer Payaro Subdivision.
12) Mr. Sher Muhammad Vessar, Assistant Executive Engineer, Kingri, Subdivision.
13) Mr. Ghulam Hussain, Assistant Executive Engineer, Irrigation Department.
14) Mr. Bhurral Shah, Assistant Executive Engineer, Irrigation Department.
15) Mr. Zahid Hussain, Assistant Executive Engineer, Irrigation Department.
16) Mr. Abdullah Soomro, Assistant Executive Engineer, Rohri Division, Moro.
17) Mr. Qurban Ali, Assistant Executive Engineer, Dadu-Moro Bridge.
18) Abdul Sami Sheikh, Assistant Executive Engineer, GBT Bund Sub-Division.
19) Mr. Sharfuddin, Assistant Executive Engineer, Irrigation Department.
20) Mr. Mukhtiar Shah, Assistant Executive Engineer, Irrigation Department.
21) Mr. Ali Gul Abbassi, Assistant Executive Engineer, Thari Mirwah, Sub Division.
22) Mr. Niaz Hussain Rajpar, Assistant Executive Engineer, Kandiaro, Sub Division.
23) Mr. Muhammad Suleman, Assistant Executive Engineer, Irrigation Department.
24) Mr. Ali Gul Phul, Assistant Executive Engineer, Khairpur East Division.
25) Mr. Sajid Ali, Sub-Engineer, Irrigation Department.
26) Mr. Naimutullah, Sub-Engineer, Irrigation Department.
27) Mr. Rahib Ali, Sub-Engineer, Moro, Sub Division.
28) Mr. Muhammad Ilyas, Irrigation Department.
29) Mr. Talib Hussain, Irrigation Department.
Appendix-D

List of Participants in Irrigation Management Strategy Workshop for Agriculture Department, held on 26th December, 2014, Morning Session at Indus Hotel, Hyderabad

1) Mr. Naushad Ali Jamali, Additional Director General AE&WM, Hyderabad.
2) Mr. Riaz Ahmed Dayo, Director Agriculture Extension, Karachi.
3) Mr. Irshad Ahmed Ansari, Director OWFM, Hyderabad.
4) Mr. Deedar Ahmed Bhutto, Director Information, Agriculture Department, Hyderabad.
5) Mr. Anwar Ahmed Pathan, Director Training, Agriculture Extension, Hyderabad.
6) Mr. Achar Keerio, Director Agriculture Extension, Hyderabad.
7) Mr. Bashir Ahmed Keerio, Director Agriculture Extension, Hyderabad.
8) Noor Muhammad Baloch, Director, Agriculture Research Institute.
9) Mr. Ashraf Ali Soomro, Director, Sindh Horticulture Research Institute, Mirpurkhas.
10) Dr. Usman Shar, Entomologist, ARI, Tandojam.
11) Dr. Liaquat Ali Bhutto, Plant Breeding, Agriculture Research, Thatta
12) Mr. Hafeez Rehman Khuro, Coordinator, Agriculture Department, Hyderabad.
13) Mr. Manzoor Hussain Samoon, Deputy Director Coordination, DG AE&WM Office.
14) Mr. Shabir Ahmed Bhurt, Deputy Director, OFWM, Thatta.
15) Mr. Ayub Burdi, Deputy Director OFWM, Matiari.
16) Mr. Ghulamullah Jarwar, Deputy Director, OFWM, Mirpurkhas.
17) Mr. Shahid Mehmood Arain, Deputy Director OFWM (WCD), Hyderabad.
18) Mr. Ghulam Nabi Kumbhar, Deputy Director OFWM/ NPIW Tando Muhammad Khan.
19) Mr. Muhammad Aslam Khan, Deputy Director, OFWM, Tharparkar.
20) Mr. Muhammad Saleem Sheikh, Deputy Director, OFWM, Tando Allahyar.
21) Mr. Shakeel Ahmed Rahimoon, Deputy Director, OFWM, Badin.
22) Mr. Muhammad Wassem, Deputy Director OFWM / NPIW, Jamshoro.
23) Mr. Abdul Sami Soomro, Deputy Director (Agriculture), OFWM Hyderabad.
24) Mr. A. Razzaque Baloch, Deputy Director Agriculture Extension, Hyderabad.
25) Mr. Nisar Ahmed Sheikh, Deputy Director, Agriculture Extension, Jamshoro.
26) Mr. Laki Bozdar, Deputy Director, Agriculture Extension, Tando Allahyar.
27) Mr. Yaqoob Jalal, Sugar Cane Specialist, Agriculture Research Institute, Tandojam.
28) Dr. Hafeez, Assistant Chemist, Agriculture Research Institute, Tandojam.
29) Mr. Abdul Qadir Khatri, Soil Chemist, SHRI, Mirpurkhas.
30) Mr. Muneer Hussain Solangi, Entomologist, SHRI, Mirpurkhas.
31) Mr. Mukhtiar Ali Channa, Soil Fertility Officer, ARI, Tandojam.
33) Mr. Hanif Ujjan, Agriculture Department, Mirpurkhas.
34) Mr. Wali Muhammad Baloch, Statistician, Agriculture Department.
35) Mr. Muhammad Usman Samoon, Agronomist, Agriculture Research Institute.
36) Mr. Dad Muhammad Baloch, Sindh Horticulture Research Institute, Mirpurkhas.
37) Muhammad Hashim Memon, Assistant Director OFWM.
38) Mr. Chetan Mal, Assistant Director, Agriculture Extension, Talluka Hyderabad.
39) Mr. Agha Deedar Hussain, AVS, Agriculture Department.
40) Mr. Gulshan Lal Oad, Assistant Director (F), OFWM.
41) Mr. Naresh Kumar, Assistant Director (F), OFWM / NPIW, Khairpur Mirs.
42) Mr. Safdar Aman, Assistant Director (F), OFWM / NPIW, Tando Muhammad Khan.
43) Mr. Lal Chand, Agriculture Officer/ Focal Person IPM, Agriculture Extension.
44) Mr. Nadeem Ahmed Koraie, Agriculture Officer PP (Reg), Agriculture Extension.
45) M. Yousif Channa, Agriculture Training Institute, Sakrand.
46) Mr. A. Ikhlas Sheikh, Agriculture Extension, Hyderabad.
47) Mr. Ghulam Mustafa Nangraj, Information Officer, Agriculture Extension, Hyderabad.
48) Mr. Nisar Memon, Assistant Director (F), OFWM, Hyderabad.
49) Mr. Touqeer Ahmed Sheikh, Agriculture Officer, Agriculture Extension, Hyderabad.
50) Mr. Faheem Ahmed Bhatti, Assistant Research Officer, Quality Seeds.
Appendix-E

List of Participants in Irrigation Management Strategy Workshop for SIDA & AWBs, held on 26\textsuperscript{th} December, 2014, Evening Session at Indus Hotel, Hyderabad

1) Mr. Babar Hussain Effendi, Managing Director, SIDA.
2) Mr. Jamaluddin Mangan, Project Director, WSIP-SIDA.
3) Mr. Jai Ram Motwani, General Manager (Operation), SIDA.
4) Mr. M. Khan Nizamani, Director General M&E Cell.
5) Mr. Anwar Ali Siyal, Director Ghotki Feeder Canal Area Water Board.
6) Mr. Ghulam Mustafa Ujjan, Director Nara Canal Area Water Board.
7) Mr. Habib Ahmed Ursani, Deputy Head, PMO-SBIP, Hyderabad.
8) Mr. Ghulam Muhammad Soomro, Farmer Member, NCAWB.
9) Mr. Javed Hakeem Memon, Executive Engineer, Phuleli Canal, LBCAWB.
10) Mr. Mansoor Ahmed Memon, Executive Engineer, Thar Division, NCAWB.
11) Mr. Abid Hussain Naich, Executive Engineer, GFCAWB.
12) Mr. Aftab Memon, Manager Revenue, SIDA.
13) Mr. Khursheed Ahmed Khokhar, Assistant Executive Engineer, GFCAWB.
14) Mr. Hizbullah Mangario, Communication Specialist, SIDA
15) Mr. Mohsin Teli, Internal Auditor, SIDA.
16) Mr. Masroor Ahmed Shahwani, Social Mobilizer/ Institutional Specialist, SIDA.
17) Mr. Aneel Shahzad, Assistant Manager, LBCAWB.
Before the monsoon Season 2011 | 23 September 2011 | 29 October 2011