

Strategies to Manage Aquifer Recharge in Balochistan, Pakistan: An Overview.

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Abstract. Balochistan plateau is dominated by the drainage system of eighteen river basins, where precipitation recharges both consolidated and unconsolidated aquifers. In eleven river basins, the groundwater levels are steadily depleting for the last three decades due to indefensible long-term groundwater extraction. The cumulative decline of water-table ranges from 2 to 3 meters/y. The most significant decrease of 60m in the last 12 years has been recorded in parts of Quetta Valley. The estimated total groundwater recharge in an average year of all river basins is 2,200 Mm³, the withdrawal is 2,657 Mm³. The groundwater overdraft in eleven river basins is 886 Mm³, whereas 429 Mm³ is available for sustainable development only in seven river basins. To enhance the groundwater recharge, many proposals have been advanced, and several studies have been carried out by different public and private sector organizations for the protection of natural resources. However, implementation of the recommendations of these studies remained limited with little progress causing severe shortages of groundwater resources. Assorted strategies have been developed by the concerned government departments for the protection of natural resources under their jurisdiction. A comprehensive provincial policy and subsequent strategy for the protection and sustainable development of natural resources in Balochistan is yet to be formed. In this paper the natural resource protection policies and strategies that are directly or indirectly associated with the surface and groundwater resources have been assessed. In addition, the federal and provincial policies, including water, biodiversity, climate change, environment, agriculture, forest, and rangeland management have been reviewed and summarized. In some of the previous strategies, certain measures have been proposed for the improvement of water resources. The measures include a ban on agriculture tube wells in urban areas, construction of storage, supply and delay action dams (DADs). As a consequence, 326 DADs with a storage capacity of 332 Mm³ were constructed in different river basins. The studies represent that in current circumstances, the DADs are the appropriate means to recharge aquifers if supported by design modifications and catchment area specific watershed management plans. For the sustainable management of natural resources of the province a comprehensive, integrated watershed management strategy and a model are presented in this paper.

Keywords: Groundwater, recharge, strategies, Delay Action Dams, Balochistan

1. Introduction

Balochistan plateau is comprised of four distinct zones, the Upper-Highlands, the Lower-Highlands, the Kachi-Nasirabad-Makran Plain and the deserts. The Upper-Highlands where altitude ranges from 1,500 to 3,700 meters above sea level (masl), has warm summer and very cold winters. The precipitation ranges from 200-250 mm/y and characterized as a semi-arid zone. The Lower-Highlands, where altitude ranges from 600 to 1,200 masl, is the zone of hot and dry summers, but the winters are extremely cold to mild. This zone is characterized as arid where precipitation varies from 100-150 mm/y. The Kachi and small plains stretch from, Nasirabad to Dera Bugti and extends from Mekran coast to Iran border, where the summer temperature reaches up to 50 °C but winters are mild. The desert zone is located in western Balochistan mostly covered with sand-dunes where the summer is hot



and arid, the windstorms make the area inhospitable. This desert zone is characterized as Hyper-arid and precipitation ranges from 0-100 mm/y. The distributions of 18 river basins of Balochistan and the location of Quetta Valley are shown in figure 1.

The geographical area of Balochistan is 44% with 5% of Pakistan's population. The provincial water assets can only be evaluated area-wise rather than population. The renewable water resources of Balochistan are about 30% per-annum of Pakistan as per geographical area. Pakistan's 87% available water is contributed by the Indus Basin Irrigation System. Balochistan receives yearly 3.75 billion m³ of water from Indus Basin canal commands, which irrigates about 1% of the provincial lands that equal to 14% of the accessible waters. The remaining 99% of the provincial land area encountered exhausted environment and degraded natural resources, water scarcity and depleting groundwater (GW), resources. The water resources vary from basin to basin, some river basins have 1/2 - 1/3 of the average water potential. The floodwater is the largest resource of water in the province, about two-thirds of total available water, but only 40% is utilized. The GW constitutes around 4% of the total water available, but this is an over-utilized resource.

The main three water sources of the province; the largest is floodwater comprise of seasonal flood flows. The second is the IBIS consists of perennial and non-perennial water resources. The third is the GW abstracted by tubewells, dug-wells, *karizes* (underground water channels), and springs. The wasteful water usage, over-exploitation of GW and frequent droughts made the water management a complex and difficult task. Despite water scarcity, the provincial government does not have the capacity to manage the available water resources. To protect the natural resources, government agencies prepared several policies during the last two decades, but no policy has been implemented in its true spirit. The policies include protection and conservation of ecosystems, biodiversity, natural resources, environment effects of climate change, forests, rangelands, agriculture, watershed, surface water and GW resource management. The common aim of all policies is to conserve natural resources and to eliminate desertification and deforestation.



Figure 1. Balochistan plateau, 18 River Basins and Quetta Valley, [1].

2. Declining of Groundwater Resources

In Balochistan, GW is almost the only source of public supply, industrial and agricultural purposes. The river basins encompassed drainage areas from 1,115 Km² of Kand River to 84,916 Km² of Hamun-e-Lora. The cumulative average yearly precipitation ranges from 66-281mm. The GW occurs in consolidated and unconsolidated aquifers, which flows from the catchment boundaries to the axis of the valleys and follows the surface drainage pattern. In river basins, the depth of GW table ranges from 5-50 m below ground surface. In an average year, the estimated GW recharge of river basins varies between 10-300 Mm³/y and the total GW recharge of all river basins is about 2,200 Mm³/y. Its utilization varies from 19-566 Mm³/y whereas its total utilization is 2,657 Mm³/y, [2]. The amount of overdrawn GW in different basin ranges from 2-396 Mm³/y and the total overdrawn from all river basins is 886 Mm³/y. The safely exploitable in seven river basins ranges from 2-273 Mm³ and the total available quantity for future exploration is 429 Mm³/y, [2]. The estimated GW budget of all river basins is presented in table 1, [2].

The excessive unplanned pumping caused continuous depletion of GW resources at an alarming rate in eleven river basins out of eighteen. The cumulative decline of the GW table in the province is 2-3 m/y. The worst example of GW depletion is represented here from Quetta Valley. In Quetta Valley the GW table is declining at a distressing rate of 1-4 m/y in different areas, especially in the context of the continually increasing human population. The monitoring results of ten years from 2005-2014 in Quetta, represent that water table declining at a rate of 1.4-2.7 m/y and a total decline varies between 14-27 m. The eleven years monitoring results characterize that water table declining at the rate of 3.7 m/y, the total decline of the water table is 41 m. The monitoring results of thirteen years from 2003 to 2015 signify that water table decline at a rate of 1-4 m/y and the cumulative decline varies from 12-53 m. The declining trend of GW table at ten monitoring points in Quetta Valley is shown in table 2, [3].

Table 1. The GW Balance in an average year of River Bains, [2].

| River Basins | Area Km ² | DAD's | | Precipitation Ave. mm | GW Balance Mm ³ | | | |
|--------------|----------------------|-------|-------------------------|-----------------------|----------------------------|-------------|-----------|---------|
| | | No | Storage Mm ³ | | Recharge | Utilization | Overdrawn | Surplus |
| Dasht | 27,690 | 20 | 31 | 125.4 | 100 | 94 | - | 6 |
| Gaj | 6,025 | 4 | 8 | 203.1 | 70 | 72 | 2 | - |
| Gawadar | 17,065 | 5 | 95 | 65.7 | 40 | 25 | - | 15 |
| H-e-Lora | 84,916 | 1 | 0 | 129.2 | 40 | 141 | 101 | - |
| H-e-Mashkel | 8,260 | 14 | 33 | 120.9 | 300 | 27 | - | 273 |
| Hingol | 35,736 | 5 | 4 | 167.2 | 200 | 168 | - | 32 |
| Hub | 8,610 | 10 | 11 | 175.8 | 80 | 88 | 8 | - |
| Kachhi | 31,495 | 13 | 4 | 116.6 | 180 | 169 | - | 11 |
| Kadanai | 4,274 | 0 | 0 | 209.2 | 30 | 115 | 85 | - |
| Kaha | 11,995 | 9 | 5 | 281.3 | 190 | 319 | 129 | - |
| Kand | 1,115 | 0 | 0 | 245.6 | 10 | 19 | 9 | - |
| Kunder | 6,224 | 5 | 1 | 244.6 | 50 | 48 | - | 2 |
| Mula | 16,262 | 6 | 6 | 142.9 | 120 | 129 | 9 | - |
| Nari | 22,298 | 47 | 24 | 243.7 | 270 | 180 | - | 90 |
| Pishin | 18,133 | 132 | 45 | 199.9 | 170 | 566 | 396 | - |
| Porali | 18,540 | 17 | 21 | 171.5 | 140 | 146 | 6 | - |
| Rakhshan | 12,339 | 5 | 10 | 125.4 | 50 | 81 | 31 | - |
| Zhob | 16,425 | 33 | 34 | 235.2 | 160 | 270 | 110 | - |
| Total | 347,402 | 26 | 332 | - | 2,200 | 2,657 | 886 | 429 |

Table 2. The decline of groundwater in Quetta Valley, [3].

| Monitoring | | Decline (m) | | |
|------------------------|-----------|-------------|----------|-------|
| Points | Years | | Per Year | Total |
| Labor Colony | 2005-2014 | 10 | 2.7 | 27 |
| Haji Saadullah CA | 2005-2014 | 10 | 1.7 | 17 |
| N-7 Old | 2005-2014 | 10 | 1.4 | 14 |
| N-3 Old | 2005-2015 | 11 | 3.7 | 41 |
| Al-Haded Quetta Cantt. | 2003-2015 | 13 | 0.9 | 12 |
| Agriculture College | 2003-2015 | 13 | 1.9 | 25 |
| Killi Nasaran Malezai | 2003-2015 | 13 | 2.1 | 27 |
| Chiltan Housing Scheme | 2003-2015 | 13 | 1.9 | 25 |
| GOR Colony | 2003-2015 | 13 | 2.4 | 31 |
| Killi Shabak K R | 2003-2015 | 13 | 4.1 | 53 |

3. Strategies and Policies for Groundwater Management

To protect the ecosystem, biodiversity and natural resources different government agencies developed Strategies and Policies (SAP) for their respective domains and jurisdiction. Individual strategies encompass to protect and conserve the environment, effects of climate change, forests, rangelands, agriculture, poverty, river basins, watershed management and surface and GW resources.

The major aim of SAPs is to conserve the natural environment and to protect desertification and deforestation. Most of the SAP components and parameters are in replication, comparatively interconnected and overlapping. The SAPs devised in last two decades mostly from 1992 to 2015 at national and provincial levels. Here we present an overarching review and analyses of twenty national and provincial level SAPs. Most of the policies were prepared by respective federal and provincial ministries in collaboration with NGOs, national and international organizations, UN Agencies, and consultants. The conservation and protection of water resources has been the focal point of all individual plans, programs and SAPs. The SAPs are simplified and major components relevant to water resources of all individual policies are summarized in the following sections. The summary of the SAPs directly relevant to Balochistan is presented in table 3.

3.1 Federal Government's Strategies and Policies

In this section we will describe the different SAPs devised by the Federal Government. Some of the SAPs are devised simultaneously for all the provinces. While, some of the SAPs are specifically for individual provinces and separately for Balochistan. The Federal Government strategies are described in the following paragraphs.

3.1.1. National Biodiversity Strategy

International Union to Conserve Nature 2015 prepared the National Biodiversity Strategy, [4]. In Pakistan, the growth in human population puts extra pressure on natural resources. Likewise, excessive use of timber and non-timber forest products, use of wood, forage and expanding agriculture causing land degradation, desertification, loss of habitat and wild fauna, and the existence of wild species. The provincial rural lands are not managed by any government agency/department. It's a major reason for ecosystem degradation, overgrazing, and deforestation. The said areas are prone to air and water erosion, reduction in fertility of soil, waterlogging, and salinity. The degradation of the resource exceeds because of water scarcity, droughts, and mismanagement of available water and land resources. The loss of habitats is a grave hazard to biodiversity and a number of species confined to isolated pockets.

The National Biodiversity Strategy and Action Plan (NBSAP) provide an assessment of biodiversity and its trend in the country. The NBSAP presents specific objectives and goals and a plan

of action along with coordinated arrangements and implementation measure. NBSAP has been prepared with the collaboration of national and provincial policy makers and planners, regional consultants and the World Conservation Union (IUCN). The NBSAP's major objective is to enhance biodiversity by the preservation of ecosystem, genetic diversity, and species. The major components of NBSAP covering different resources management and control regimes are presented in box 1.

Table 3. National and Provincial Strategies and Policies.

| S# | Year | Strategies and Policies | Sponsored Agencies | |
|------------------------------------|------|---|--------------------|----------------------------------|
| National Strategies and Policies | | | | |
| 1 | 2015 | National Biodiversity Strategy | GOP ^a | IUCN |
| 2 | 2015 | National Forest Policy | GOP | MO ^c Climate Change |
| 3 | 2014 | Millennium Development Goals | GOP | G-Water ^d Partnership |
| 4 | 2012 | National Sustainable Development Strategy | GOP | UNDP |
| 5 | 2012 | National Climate Change Policy | GOP | MO Climate Change |
| 6 | 2010 | National Rangeland Policy | GOP | MO Environment |
| 7 | 2005 | National Environmental Policy | GOP | MO Environment |
| 8 | 2004 | Agricultural Perspective and Policy | GOP | MO FA ^e & Livestock |
| 9 | 2002 | Pakistan Water Sector Strategy | GOP | MO Water & Power |
| 10 | 1992 | National Conservation Strategy | GOP | IUCN |
| Provincial Strategies and Policies | | | | |
| 1 | 2014 | Provincial Water Policy | GOB ^b | I&P ^f Department |
| 2 | 2013 | Poverty Alleviation Strategy | GOP | PPA ^g FUND |
| 3 | 2011 | Sustainable Development Policy | GOB | IUCN |
| 4 | 2010 | Participatory GW Management Strategy | GOB | Techno Consult Int. |
| 5 | 2010 | Ground Water Management Action Plan | GOB | Techno Consult Int. |
| 6 | 2006 | Integrated Water Resources Manag. Policy | GOB | I&P Department |
| 7 | 2000 | Balochistan Conservation Strategy | GOB | IUCN |
| 8 | 2000 | Strategy to Improve Governance | GOB | GKW Consult |
| 9 | 2000 | Water Sector Strategy | NGO | Taraqee Foundation |
| 10 | 1992 | Environmental Policy | GOP | Soil Survey Pakistan |

^aGOP = Government of Pakistan; ^bGOB Government of Balochistan; ^cMO = Ministry of; ^dG-Water = Global Water;

^eFA = Food & Agriculture; ^fI&P = Irrigation and Power; ^gPPA = Pakistan Poverty Alleviation

Box 1. The major components of NBSAP, [4].

1. Biodiversity awareness
2. Gender, poverty and biodiversity nexus
3. Biodiversity in national planning and policy
4. Terrestrial ecosystems, habitats, and species
5. Forest ecosystems
6. Inland wetland ecosystems
7. Coastal and marine ecosystems
8. Sustainable agriculture and agrobiodiversity
9. Sustainable production and consumption
10. Biosafety – Emerging issues and challenges

3.1.2. National Forest Policy

Ministry of Climate Change in 2015 prepared the National Forest Policy [5]. The country's land area under forests cover is only 5%. In most parts of the country the climate, water and soil conditions are not suitable for large-scale afforestation. Within their jurisdiction, the provincial governments developing and protecting forests. The country's vulnerability to climate change and its influences is quite evident. To protect the extreme environmental impacts, modification and adaptation procedures are the mainstay of the forest policy.

The forestry's scope should be extended immensely as it provides efficient measures to climate change as a global issue. It also tackles desertification together with air and water pollution and loss of biodiversity. Pakistan has various commitments and obligations as a signatory of international agreements and conventions. The commitments are related to forestry that requires national action plans, commitment and dedication of the provinces. An umbrella forest policy is prepared by the Federal Government for bolstering provincial forest policies in view of climate change. The objectives of the forest policy are highlighted in box 2.

Box 2. The major objectives of the forest policy; modified after MO Climate Change, [5].

1. Public awareness of socioeconomic, cultural and ecological standards of forests
2. Mass afforestation to increase forest coverage at global standards
3. Deforestation by regulating the trade and movement of timber
4. Establish protected areas and ecological corridors
5. Carbon footprint abating of energy in the economic sector
6. International convention's execution related to climate change, biodiversity & forestry
7. Consistent scientific planning of forests, education, and research

3.1.3. Millennium Development Goals

The Global Water Partnership has prepared Millennium Development Goals in 2014, [6]. The UN Conference on Sustainable Development organized in Rio de Janeiro in 2012, for a consultative exercise to consider post-2015 development framework. The outcome of the conference was to advance an agenda for member countries in the sustainable development through a consultative process for post-2015. It has been planned to create an intergovernmental procedure for the Sustainable Development Goals (SDGs) for General Assembly in 2015.

The SDG consultations covered eleven themes including water. The UN-Water, in collaboration with the Global Water Partnership (GWP), developed a document for the Open Working Group consultations held in 2014. A consultative procedure commenced in 30 countries, including Pakistan. The GOP and the Pakistan Water Partnership extended backing and possession to the UN Procedure and hold a consultation process. The Millennium Development Goals set for Pakistan, the progress achieved by 2013 and the processes to be achieved by 2030 was discussed. The outcomes of the workshop are outlined in box 3.

Box 3. Millennium Development Goals for drinking water, sanitation & hygiene, [6].

Access to safe drinking water, sanitation, and hygiene;

1. Investment with Public-Private Partnership to improve services for WASH
2. Enforce governance to control water thefts
3. Civil-Society contribution in delivering services to the poor communities

Water Resources;

1. Institutions to ensure sustainable withdrawal and uses of surface and GW
2. Develop pricing structure for domestic, agriculture, and industrial waters
3. Address water demand and equity in water accessibility and increase storages

Water Governance;

1. Acquire consensus for the formulation of National Water Policy
2. Strict water governance laws for the National Water Policy
3. Strengthen the water sector to accomplish targets

Managing Waste Water and Pollution;

1. Convert waste into wealth
2. Follow the principle of 3R: Reduce – Recycle – Reuse
3. Coordinate private sector for the management waste
4. In sub-sectors control and minimize pollution

3.1.4. National Sustainable Development Strategy

National Sustainable Development Strategy (NSDS), Pakistan's Pathway to a Sustainable and Resilient Future was developed by the GOP and United Nations Development Program (UNDP), [7]. This Strategy was established that climate change relates to sustainable development therefore careful and target-oriented planning is necessary.

Pakistan contributes 0.8% to global emissions and sufferer of worst casualties, a fact reflected in the various indexes which monitor climate change. The serious impacts are increasing in the frequency and severity of floods, droughts, cyclones and heat waves which cause severe damage to the lives, property, and agriculture. The NSDS implementation is a challenge to evolve, it may not impose. It can effectively reset the country's development and growth trajectory on to a sustainable pathway. A continued support and policy shift towards sustainable development concerns, through a network of institutions with the highlighted needs of the country and the global sustainable development program. The NSDS related to Environmentally Sustainable Development and the growing issue of Climate change and Sustainable Development are outlined in box 4.

Box 4. National Sustainable Development Strategy, [7].

-
- Sustainable and inclusive economic growth
 - Social and human development
 - Environmentally sustainable development
 - 1. Environmental sustainability
 - 2. Air quality, water pollution, and water quality deterioration
 - 3. Management of solid and hazardous waste
 - 4. Forestry and biodiversity protection, and land degradation
 - The issue of sustainable development and climate change
 - 1. Natural disasters and risk reduction
 - 2. The economic costs of adaptation and sustainable development
 - 3. Sustainable development and climate mitigation
 - 4. Sponsoring sustainable development
 - 5. Institutional response to climate change
-

3.1.5. National Climate Change Policy;

The National Climate Change Policy (NCCP) was developed by the Ministry of Climate Change, [8]. The Pakistanis are experiencing the impacts of climate change in all the provinces and across the country. The devastating floods, prolonged droughts, and extreme temperature waves are happening simultaneously in different parts. These climatic changes come along with extensive values and huge economic burden on effective communities.

The NCCP broadly covers the probable challenges and effects of climate change for future adaptation and mitigation. It offers an outline and an action plan for the climate change agenda and projects. The policy addresses the present and future expected climate change threats to various sectors in the country. The policy represents the adversative influences of climate change and extreme events and country's vulnerability. The implementation framework of NCCP document was prepared in 2013, [9]. The main objectives of Pakistan's Climate Change Policy are presented in box 5.

Box 5. Pakistan's Climate Change Policy, [8].

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- 1. Sustainable economic development to tackle challenges of climate change
 - 2. Gender-sensitive and pro-poor adaptation of cost-effective means
 - 3. Ensure food, water, and energy security to eliminate challenges of climate change
 - 4. Minimize extreme weather events effects like floods, tropical storms, and droughts
 - 5. On climate change reinforce inter-ministerial coordination mechanisms
 - 6. Increase the skills, awareness, and institutional capacity of communities
 - 7. Sustainable conservation of natural resources
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3.1.6. National Rangeland Policy;

The National Rangeland Policy prepared by the Ministry of Environment, 2010, [10]. The rangelands play an important role in the livelihoods of communities through the rearing of animals and gaining different products and facilities. The rangelands provide feed and forage to livestock. The ranges useful for water resources, recreation activities, wildlife, and fish habitat. The rangelands enhancing water infiltration, leading to GW recharge, sustained base-flow of streams and confine soil erosion. The social and economic parameters, ecological stability and shielding ecosystems are related to rangelands. In Pakistan, the rangelands span-over 60% of the total land area of the country, while in Balochistan about 79% of the total area, [11].

The ranges inhabitant a fragile ecosystem and due to overgrazing the productivity of rangelands and the biodiversity have declined considerably. Due to mismanagement of rangeland soil erosion augmented, land degradation accelerated, biodiversity and reduced productivity. The overall goal of the policy is to rehabilitate and restore the rangelands and pastures and increase productivity. Also, to enhance environmental and regulatory functions, conserve rangeland biodiversity and to mitigate negative impacts of climate change. The rangelands policy comprised eleven important thrusts described in box 6.

Box 6. The Rangelands Policy Thrusts; modified after MO Environment, [10].

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1. Monitoring and assessment rangeland resource
 2. Integrated rangeland resource planning
 3. Rehabilitation and management of range resource
 4. Increase forage production on other lands
 5. Elevation of rangeland enterprises
 6. Rangeland management for sustainable base-flow and curtail sedimentation
 7. Rehabilitation ecosystem to conserve biodiversity
 8. Global warming and climate change impact mitigation
 9. Train farmers and capacity enhancement of relevant stakeholders
 10. Introduce range research, technology development, and transfer
 11. Generate financial resource
-

3.1.7. National Environmental Policy

The National Environment Policy (NEP) was prepared by the Ministry of Environment, [12]. The policy addresses the environmental issues facing the entire country. The environmental issues are related to pollution of fresh and coastal water resources. The other environmental issues are climate change, mismanagement of waste, loss of biodiversity, desertification, and deforestation, aridity and natural disasters. The policy addresses cross-sectoral issues and environmental degradation and meeting international obligations. The policy developed to conserve, protect, and restore the environment to improve the quality of people's lives through sustainable development. The major sectors of the NEP are summarized in the box 7.

Box 7. National Environment Policy, [12].

Sectoral guidelines

1. Water supply and management
 2. Forestry, biodiversity and protected areas
 3. Climate change and ozone depletion
 4. Agriculture and livestock
 5. Multilateral environmental agreements
-

Cross-sectoral guidelines

6. Population, poverty and environment
 7. Health, gender and environment
 8. Trade, local governance and environment
 9. Natural disaster management
-

3.1.8. Agricultural Perspective and Policy

The Agricultural Perspective and Policy was prepared by the Ministry of Food, Agriculture and Livestock, [13]. The agriculture sector is the lifeline and the single largest sector of Pakistan's economy. It contributes 24% to the GDP and employs 48.4% of the labor force. It also contributes 70% of the foreign exchange earnings through the export of raw materials, semi-processed and processed agricultural products. About 68% of the population live in rural Pakistan and depends upon agriculture for sustenance. Pakistan is facing a comparatively low productivity level of crops due to gaps in yields of crops on a different type of farms and because of water availability in dry and wet years. To smoothen the supply of agriculture water it seems appropriate to tame the river flow system. A great irrigation system was set up to divert and distribute water supplies through canals from the Indus Basin Irrigation System established by link canals and water reservoirs. The recent droughts exposed the vulnerability of the IBIS and additional storage facilities felt to increase supply with operating flexibilities. Water supply systems are expensive, groundwater development is at its absolute limits, and water conservation may add 10-15% of total supply by the enhanced efficiency of an irrigation system which is 40%. To increase the agricultural productivity of high value crops, a number of policies and strategy measures were established. The Pakistan's Agricultural Policy concentrated on the sustainable domestic food security. Special emphasis was given to water management, conservation and increase in the productivity. The water management and conservation in agriculture is linked to many factors as listed in box 8.

Box 8. Water Management and Conservation, [13].

1. River water diversions system
2. Water supply situation and mobilization
3. Water requirements and conservation
4. Water vision and water issues
5. Water management strategy and program
6. Improvement of water productivity

3.1.9. Pakistan Water Sector Strategy

The strategy for the water sector was prepared by the Ministry of Water and Power, [14]. Pakistan did a lot of efforts for the development of surface and groundwater resources. In this regard, many projects accomplished to strengthen the infrastructure for water delivery system, constituting and world's biggest canal irrigation system developed. With the increase in population, the country's water demand is also increasing, ultimately the country becoming a resourceful country to a water scarce country. It's required to manage water resource to ensure sustainable supply to all sectors.

The government of Pakistan and the Asian Development Bank jointly introduced the Water Resources Strategy Study. The study was commenced by the Office of the Chief Engineering Advisor/Chairman, Federal Flood Commission, Ministry of Water and Power. The major objectives of the study are to formulate a roadmap for water sector development for a proficient delivery system and conservation of resources for future demands.

The government has addressed the water sector and took many incentives in this regard. The important incentives include Ten-Year Perspective Plan of Planning Commission, [15]; Vision 2025 of Water and Power Development Authority [16], and the National Water Policy of the Ministry of Water and Power [17]. The national water sector profile covers the sub-sectors including; development of water resources, rural and urban water supply and sanitation, pollution control, industrial water supply, irrigation and drainage, environmental and flood protection. The Pakistan Water Sector Strategy provides a roadmap for the sectors future needs based on planning approach. The strategy is applicable across the water sector and the main points are summarized in box 9.

Box 9. The Water Sector Strategy; modified after Ministry of Water and Power [14].

1. Strengthen agencies responsible for water resource delivery
2. Ensure private sector participation and community involvement in the water sector
3. Minimize spending in the water supply by obligatory duties on water services
4. Confirm financially self-sustaining services in all sub-sectors
5. Improve private sector investment in water supply, improve data in the water sector
6. Ensure public awareness and education on water issues
7. Adopt the principles of IWRM, develop water storage facilities
8. Promote managing watersheds for sustainable water resources
9. Ensure water utilization for socioeconomic growth
10. Progress conditions of equity in access to all sorts of water utilization
11. Improvement in water quality, coverage, and dependability of domestic supply
12. Increase water quality of water bodies, rivers, and GW by regulations
13. Ensure water access to fulfill the community needs, in all water sectors
14. Ensure sufficient water use for agriculture and food requirements
15. Improve productivity and expenditures in irrigation through Farmer Organizations
16. Develop hydropower, control waterlogging, salinity and disposal of saline drainage

3.1.10. National Conservation Strategy

The National Conservation Strategy (NCS) was developed by the International Union to Conserve Nature, during 1983-1992, [18]. The NCS is formulated for to environmental conservation of the country. In addition to protecting the natural resource and incitation of environmentally friendly projects. The guiding principles of the NCS ensure integrated exertion environment protection and to conserve the natural resources. The strategy provides wide-ranging references to relevant government departments, public and private sector corporations, donor agencies, financial institutions to work collectively for sustainable development in the respective field of studies. The NCS has eight core program areas for the priority implementation are given in box 10.

Box 10. Core programs of National Conservation Strategy, [18].

1. Improve soils in croplands, increase irrigation efficiency
2. Protecting watersheds, supportive forestry & plantations
3. Rangeland restores and livestock improvement
4. Shielding water bodies and biodiversity conservation
5. Developing and deploying renewable
6. Preventing pollution, manage urban wastes
7. Integrating population and environmental programs
8. Preserving cultural heritage

3.2 Provincial Government Policies

In the provinces, the provincial governments are responsible for the management of natural resources. The provincial government of Balochistan devised different strategies for the management of natural resources. The SAPs devised by the Balochistan Government are described in the following paragraphs.

3.2.1. Provincial Water Policy

The Provincial Water Policy was prepared by the Irrigation and Power Department (IPD), [19]. The provincial IPD, Government of Balochistan has a mandate and responsibility to ensure adequate and sustainable water resources management through the holistic development and efficient use of available and new water resources. The IPD is also engaged with rainwater harvesting through efficient watershed management, and to curtail uncontrolled withdrawal of GW by 2030. The

improvised cropping patterns for suiting to the environment and water situation and the use of spate irrigation system is essential. Introduction of efficient irrigation technology is mandatory. The efficiently plan and develop water budgets to meet the requirement of different sectors on the actual requirement basis. In addition, institutional reforms, capacity building through advanced learning and research at all levels, effective response against the challenges are also the responsibilities of the IPD. To achieve the defined targets, the Irrigation and Power Department has formulated the Provincial Water Policy to effectively encounter the immense challenges. The basic document of water policy was approved by Provincial Cabinet, but the same has not been transformed into an Act for legal coverage. The provincial water policy is aimed to achieve certain objectives, presented in box 11, [19].

Box 11. Major objectives of the Provincial Water Policy, [19].

1. Efficient conservation and management of available water resources
2. Harnessing of flood and rainwater through efficient watershed and surface water management and development of surface water bodies
3. Efficient GW recharge measures to arrest sharp depleting GW levels
4. Increase of GW exploitation in areas where potential exists
5. Measures for water losses, equitable water distribution among beneficiaries
6. Efficient drainage system to mitigate waterlogging and salinity
7. Identification of technically feasible and economically viable and community-oriented schemes through professionals and timely completion of the projects
8. Institutional reforms and capacity building to make the organization and professionals equally dynamic and responsive future challenges ahead for assuring the sustainability of water resources

3.2.2. Balochistan Poverty Alleviation Strategy

The Balochistan Strategy organized by the Pakistan Poverty Alleviation Fund, [20]. Being least developed province, Balochistan needs integrated development approach through strengthening related institutions for the development and social progress. To address the current socioeconomic and political malaise in the province, Pakistan Poverty Alleviation Fund (PPAF) started consultative processes for community involvement, politicians, government departments and local NGOs. Ultimately, the PPAF developed a proficient organic development strategy for deprived communities of Balochistan. The main objective of the strategy is to improve the socioeconomic conditions of the community empowerment. It's imperative to bring them to the rural communities in the mainstream by transformation and involvement in decision making. The preservation and respect to the local culture, traditions, customs and identities are the focal point during the working norms with the communities. The PPAF had the experience to assist diverse communities to improve their skills, capabilities and loud their voices take part in the development process. The environmental supporting functions are outlined in box 12 along with strategy goals.

Box 12. Poverty Alleviation Strategy goals & environmental supporting functions, [20].

| | |
|---------------|--|
| Gole-1 | Hunger and poverty eradicate |
| Goal 2 | Attain primary level education |
| Goal 3 | Encourage gender equality and women's involvement |
| Goal 4 | Diminish child mortality |
| Goal 5 | Advance maternal health |
| Goal 6 | Eliminate malaria, HIV/AIDS, and other diseases |
| Goal 7 | Ensure sustainable environment |
| Environmental | Water conservation, supply, and sanitation, and Kariz system |
| Supporting | Management of sustainable water resources & dispersing processes |
| Functions | Disaster preparedness, flood water storage & drought mitigation |
| | Skill development and sustainable management practices |

3.2.3. Sustainable Development Policy

The Sustainable Development Policy prepared by the International Union to Conserve Nature, [21]. The Integrated District Development Vision (IDDV) established by a consultative process. The existing situation, challenges, measures, issues, opportunities, and constraints are related to governance, natural resources, social sectors, disaster management and economic development. The prime objectives of the IDDV are to the sustainability of natural resources, environment protection, and sustainable development. The water supply, sanitation, healthcare, population, settlements, education, industry, commerce, energy, mining, wildlife, forests, poverty eradication, protected areas, and governance is the prime sectors.

The air, water, food and relevant products of daily consumption and trade are required for natural resources to sustain life. The socioeconomic and the survival of rural communities depend on natural resources. The mismanagement of natural resources and natural disasters such as droughts and floods may reduce the productivity which affects them badly. The climate, water, land-use, agriculture, livestock, rangelands, forests, wetlands, are the key elements of natural resources of rural communities. The development agencies are working to combat the depletion of natural resources and for the sustainable development. The optimistic characteristics of districts are people, forests, agriculture, rangelands, watersheds, biodiversity, mineral deposits and protected areas. The aridity, fast depleting GW, periodic and overgrazed and degraded rangelands, low productivity of livestock, rugged terrain and droughts are major problems. The population density is very high, it's required to stop and reverse the degradation and depletion of natural resources by promoting and utilizing alternate resources. The major issues projected to address on a priority basis for the sustainable development of the natural resources is presented in box 13.

Box 13. Key issues for protection and sustainable development of natural resources, [21].

1. Extreme aridity and periodical drought.
 2. Fast depleting GW because of indiscriminate mining, subsidy on the power supply for agriculture, and changing the land-use in the recharge zones.
 3. Depleted, overgrazed, low-productivity of livestock and rangeland mismanagement.
 4. The degradation and decline in wildlife populations and habitats.
 5. Degradation of the forest, deforestation due to overexploitation and mismanagement.
 6. Communities' poverty related to degraded natural resources for their livelihood.
 7. GIS Coordinators, GIS-based information databases, and lack of scientific research
 8. Insignificant funds for natural resource management in livestock, rangelands, agriculture, wildlife, forests, and for protected areas.
 9. Exploitation of water resources, gas, firewood, and electricity.
-

3.2.4. Groundwater Management Action Plan

The Groundwater Management Action Plan was prepared by the Techno-Consult International, [21]. The Balochistan Small Scale Irrigation Project (BSSIP) sponsored by the World Bank and GW Management Action Plan prepared for Pishin Lora Basin and implementation of a Pilot Program in Quetta Sub-basin. The study was conducted by the Techno-Consult International with the collaboration of Associated Consulting Engineers and CAMEOS Consulting Engineers. The consultants prepared an action plan that comprises several compounding factors which critically influence the management of provincial water resources and provide a firm basis for justifying the need for a GW management action plan. The prime goal of the management plan is to arrest the declining trend in water levels and deterioration of its quality and to stabilize the system at a certain level as determined with the consultation of stakeholders through structural and nonstructural measures. The management strategy includes exact assessment of the resource and prioritizes sectors and adoption of measures for management and utilization of the resource. The major GW management issues are given in box 14.

Box 14. The GW management action Plan, [21]

-
1. Water Resource Assessment and Monitoring
 2. GW Level and Quality Monitoring
 4. Institutional Limitations and Lack of Coordination
 5. Poor Governance
 6. Enforcement of Legislation
 8. Stakeholder Consultation
 9. Political Involvement and Malpractice
 10. Advanced Technology
 11. Poor Cost Recovery
 12. Lack of Participatory GW Management
-

3.2.5. Participatory GW Management Strategy

The Participatory GW Management Strategy was drafted by the Techno Consult International, [22]. In Balochistan, no GW management system exists, at the watershed level, it is a local problem and needs to be analyzed and managed at local level. The communities should involve in managing GW with a holistic approach of a natural resource. The primary goal of the management is to arrest the declining trend in GW levels. The system must be stabilized at a certain level determined with the consultation of all the stakeholders through structural and nonstructural measures. A clear management strategy, including exact assessment of the resource, prioritization of use for specific sectors and adoption of measures for management/utilization of the resource specifically during drought should be adapted. The regulatory and enforcement mechanisms for management are deemed to fail in the developing economies. The last option is to involve local communities to educate and motivate the people to adopt sustainable means to use GW. The participatory GW management strategy must be adopted to tackle the problem at the grass root level. Farmer organizations formed for the small-scale irrigation schemes would also be motivated to start the GW management activities in the command and catchment areas with properly defined roles. Hydrologic principles, GW flow, monitoring of water table should be postulated with the assistance of farmers, and tentatively calculated monthly GW budgets. The major points of the participatory GW management strategy are given in box 15.

Box 15. Participatory GW Management Strategy; modified after Techno Consult Int., [22].

-
1. The Regulatory and Enforcement Mechanisms
 2. User participation in GW Resource management
 3. Social Awareness for GW Management
 4. Knowledge of aquifer, GW situation and implications of GW depletion
 5. Historical changes in land use, reliance on various water sources and pressure on GW
 6. Participation rural communities for monitoring GW and preparing water budget
 7. Encourage community to manage the GW resources as a common commodity
 8. Communities in rural and urban areas are aware of the pressure on GW resources
 9. Rural and urban tubewells operators and users understand the GW depletion rates
 10. Communities develop and adopt mechanisms for community management of GW
 11. Communities adopt measures to conserve water and economies in their use of water
 12. Tubewells owners know the benefits of adopting high-efficiency irrigation systems
 13. Urban communities understand the implications of GW exploitation for sustainability
 14. Stakeholders understand why the power subsidy needs to be addressed
 15. Participatory Hydrologic Monitoring and Micro Planning
-

3.2.6. Integrated Water Resources Management Policy Balochistan

Integrated Water Resources Management (IWRM) approach utilized to formulate the Water Policy by Irrigation and Power Department, [1]. The IWRM Policy comprising fifteen policy thrust areas, which is vital for improvement and sustainability of water resources. The policy thrust areas were recognized

by assessing sub-sectors, issues of water use. The assessment is a real-world approach as compared to the traditional one that focuses on water resources.

The effective implementation of the policy will help various stakeholders to implement the policy for their relevant sub-sectors. To evaluate issues and formulating policy and reforms, the water-poverty-environment framework utilized as evaluation criteria. The basinal approach is recommended to manage the water resources in a complete way. For basinal planning, the watershed-water-farming systems were followed to enhance water productivity and water use sustainability. The modified twelve-policy thrust area for the IWRM Policy are given in box 16.

Box 16. IWRM Policy Thrust Areas, [1].

-
1. Water availability and development potential
 2. Water resource monitoring, assessment & demand management
 3. Linking water development with IWRM approach for agriculture
 4. Crops and cropping pattern adjustment with water availability
 5. Environmental water management
 6. Cost recovery of irrigation infrastructure
 7. Cost effectivity of water conservation interventions
 8. Endorsing inter-provincial cooperation
 9. Community participation
 10. Institutional strengthening and restructuring
 11. High-efficiency irrigation systems
 12. GW management and development
-

3.2.7. Balochistan Conservation Strategy

Balochistan Conservation Strategy (BCS), prepared by the Planning and Development Department of the Government of Balochistan in collaboration with IUCN, [23]. Balochistan faces challenges with major environmental issues and climate-change challenges. The shortage of water, degraded pastures and forests have been the subjects of concern for many decades. The settlements categorized by poor planning, contaminated water supplies, air pollution, inappropriate sanitation and waste management services. With the increase in population, the situation becomes worse as the urbanization accelerated.

The BCS devised to protect the natural environments of the province through community participation and involvement. The strategy designed to tackle the issues of socioeconomic development based on sustainability and conservation of natural resources. The overall goal of the strategy is the welfare of communities and protecting ecosystems, the entire strategy related to water resources of the province. The principles and objectives of the BCS are to provide a workable strategic plan for environment conservation and sustainable utilization of natural resources. The Strategy was also meant to promote social change for environmental protection, natural resources, and biodiversity. It's also facilitating access information for better decision-making and to improve the mechanisms for endorsing public awareness and support for the sustainability of natural resources. The modified action agenda of the BSC is comprised of seven core programs given in box 17.

Box 17. The core action agenda of the BCS, [23].

-
1. Improve governance, effective institutions, and authentic data management
 2. Controlling depletion and pollution of GW increasing irrigation efficiency
 3. Agricultural sustainability and poverty alleviation
 4. Managing rangelands and enhancing the productivity of livestock
 5. Sustainable planning and management of urban areas
 6. Sustainable environment-friendly development
 7. Conserving biodiversity, wetlands rehabilitating and forests sustainably
-

3.2.8. Strategy to Improve Governance

In Balochistan, all water supply schemes depend upon GW including Quetta Water Supply Scheme. Over-pumping from tubewells at a rate that exceeds the natural recharge, lead to a situation that the aquifers have exhausted in almost all parts of the province. If exploitation continues at current trends considerable water losses and shortcomings in resource management aggravate the situation. Responding to these conditions, the Government of Balochistan has decided to carry out the "Quetta Water Supply and Environmental Improvement Project", with Technical Assistance (TA), from the Asian Development Bank and GKW Consult, [24]. The TA is to prepare water resource management projects for conservation and development of Quetta. The TA assessed various policy options and institutional arrangements to encourage efficient water allocation by consumption-oriented pricing.

The actual institutional arrangements in Balochistan, characterized by a multitude of institutions interfering in the sectors concerned, and with overlapping responsibilities and insufficient coordination are the main reason. In the absence of coherent water resource and environmental management policies resulted in the inadequate performance of the operating agencies. Institutional strengthening, streamlining of responsibilities and capacity-building for political as well as an operational level are an important precondition to achieving rational water resource and environmental management. The TA proposed institutional setup at the upper level by the establishment of a single Water Regulatory Authority by merging BWASA & PHED. Like BIDA, an authority may be created as Public Health Engineering Authority to effectively manage the water resources in rural and urban levels. It is proposed that the Balochistan Water Resources Management Agency be established to coordinate the planning, evaluation, and monitoring of plans for the integrated development of the land water and the underground resources. The Balochistan Water Board should be established to prepare, implement, and monitor the plans. The proposed institutional setup to improve governance summarized in box 18.

Box 18. Proposed institutional setup to improve water governance, [24].

-
1. Balochistan Water Board, (BWB);
Establish by reconstituting provincial water board to formulate policies and rules
 2. Balochistan Water Resources Management Agency, (BWRMA);
Establish by upgrading Bureau of Water Resources as an executing agency
 3. Existing District Water Committee;
Reconstituted for the implementation of policies at the district level
 4. Water Resources Agency;
Act as the board's executing agency, organized into three functional departments
 - 4.1 *Water Resources*;
For monitoring, research, planning, project and technical specifications
 - 4.2 *Water Rights and Licenses*;
Technical approvals, contracts, legal affairs and water conservation
 - 4.3 *Administration and Finance*;
Personnel, revenues, finance and general affairs
-

3.2.9. Water Sector Strategy

The water sector strategy formulated by Taraqee Foundation [25], Taraqee is a Quetta based local NGO, working in Balochistan since 1994. The Foundation has been actively engaged in grass root level activities in the community and physical infrastructure, microfinance, basic health services, gender and advocacy, education, child protection and the environment. The foundation recognized the fact that water due to its multi-faced roles in the economic and health sectors significantly affects the poverty levels of marginalized communities. Considering that water is a finite resource, the water strategy strives to create a more sustainable water resource base in the province. The strategy will encourage communities to take part to conserve and protect natural resources, diversity in shared habitats. The communities should learn from nature and natural processes to attain environmental health, social comfort, and economic benefits. The strategy helps to maintain the sustainability of

natural resources, maintaining ecosystem, ecological integrity and provide appropriate conditions to maintain self-sustaining communities in a better ecological environment. The water strategy of Taraqee Foundation is based on certain principles described in box 19.

Box 19. The guiding principles of the Water Sector Strategy, [25].

-
1. Promoting good governance in the water sector
 2. Empowering communities to become self-sustaining
 3. Ensuring equity in decision making
 4. Enabling indigenous and traditional knowledge and water rights
 5. Improving security and reducing conflict
 6. Ensuring Women's participation
-

3.2.10. Provincial Environmental Policy

The provincial Environmental Policy was prepared by the Soil Survey of Pakistan, [26]. Environmental Profile of Balochistan presented a firsthand information about the gloomy situation of degraded environmental conditions. Desertification is well advanced and accelerated by human and small stock population explosion as well as by excessive pumpage of GW. The decline of biodiversity is also associated with desertification process. The policy stated that the GW decline and degradation of natural resources and pastures will demise the small stock industry and decrease the productivity of GW-based orchards. The predicted ecological disaster also implies the economic collapse of the natural resource-based economy. The existing forests and rangeland degradation, revegetation, GW depletion, salinization, erosion, and biodiversity decline are eminent in every part of the province. The effectiveness of legislation and Public Administration is achieving poor environmental sustainability. The first objective of the provincial environmental policy is a sustainable use of renewable natural resources and the safeguarding of the environmental quality. The second objective is the safeguard of environmental quality, the chemical and biological quality of water, air, and soil in relation to human health. The main points of the policy are summarized in box 20.

Box 20. Provincial Environmental Policy, [26].

-
1. Integrating population and environment programs
 2. Deforestation of watersheds and depletion of aquifers
 3. Desertification and de-vegetation of rangelands
 4. Waterlogging and Salinization of irrigated lands
 5. Exploitation of marine and coastal resources
 6. Declining of wildlife habitats, wild flora and fauna
 7. Damaging mining practices, water and air pollution
 8. Unplanned urban settlement and industrial growth
 9. Unmanaged urban and industrial solid wastes
-

4. Outcomes of previous strategies

The main objective of SAPs are the conservation, restoration and efficient management of environmental resources. The integration of natural resource considerations in policy making and planning processes. The capacity building of government agencies, NGOs and other stakeholders at all levels for better management of water resources. For sustainable natural resources management from water governess to community empowerment are integral part of SAPs. Specific measures have been proposed in previous strategies for the management of surface and GW resources. The measures included, ban on agriculture tube wells in urban areas, development of new water resources, construction of water storage and delay action dams (DADs) etc.

4.1 Groundwater Recharge

For groundwater recharge the construction of DADs has been proposed in different strategies, [27]. Subsequently, 326 DADs with a storage capacity of 336 Mm³ were constructed as shown in table 1. The construction of 100 DADs is in progress and approximately 80% work has reportedly been completed. To assess recharge through DADs, studies were conducted on 14 and 25 dams during 1997 and 2008 respectively, [28]. The studies show that estimated seepage of GW through fourteen DADs was 5.46 Mm³/y and 28.38 Mm³/y from remaining twenty-five DADs. The estimated discharge through Karizes located at the downstream of 25 DADs increased from 6.86 Mm³/y to 24.27 Mm³/y, table 4. These studies represent that in current circumstances, the DADs are appropriate means to recharge aquifers if supported by integrated watershed management strategies. The effectiveness of DADs may further be enhanced by increasing the height of the dam and storage capacities to supply for downstream community utilization. The GW recharge may also be increased by introducing outlet systems in the dams by releasing sediment-free water for recharging through river beds.

Table 4. GW seepage from DADs and Kariz Flows, [28].

| Delay Action Dams | Water Depth (m) | Seepage (000, m ³) | | Kariz Flow (000, m ³) | |
|---------------------|-----------------|--|--------|-----------------------------------|--------|
| | | Before | After | Before | After |
| 1 Balozai | 5.9 | No seepage studies conducted before the construction of DADs | - | 89 | 1,020 |
| 2 Gharagai | 5.4 | | 993 | 107 | 776 |
| 3 Ghazloona | 0.8 | | 927 | Dry | Dry |
| 4 Lalai | 6.7 | | 1,042 | 179 | 1,053 |
| 5 Nari Kach | 11.0 | | 983 | Dry | 1,539 |
| 6 Batogi | 1.2 | | 881 | - | - |
| 7 Chill Bagho | 1.9 | | 1,188 | - | - |
| 8 Sangar | 0.5 | | - | 268 | 1,062 |
| 9 Wulgi | 2.0 | | 1,088 | - | - |
| 10 Akhter Nika | 10.9 | | 2,047 | 2,233 | 5,771 |
| 11 Chinjann | 1.7 | | 1,284 | 268 | 853 |
| 12 Darloon | 1.9 | | 574 | 89 | 882 |
| 13 Tore Khezai | 4.3 | | 1,331 | Dry | Dry |
| 14 Amach | 1.1 | | - | Dry | 292 |
| 15 Isplangi | 1.5 | | 1,111 | - | - |
| 16 Piyyan | 2.2 | | 563 | - | - |
| 17 Brewary | 2.3 | | 359 | - | - |
| 18 Hangi & Takhtani | 3.4 | | 405 | - | - |
| 19 Tangi Dabari | 10.2 | | 1,103 | Dry | 980 |
| 20 Kapip | 4.1 | | 10,706 | - | - |
| 21 Babar Wulmai | 8.7 | | 748 | 500 | 953 |
| 22 Kawas | 5.8 | | - | 535 | 4,203 |
| 23 Zandra | 2.1 | | - | Dry | 1,024 |
| 24 Aghbargi | 9.4 | | 1,045 | 357 | 1,463 |
| 25 Kannar | 0.5 | | - | 2,233 | 2,401 |
| Total | - | | 28,378 | 6,858 | 23,980 |

4.2 Mismanagement of Natural Resources

In Balochistan, overexploitation of natural resources and climate change affected the natural resources, communal life, and economy of the province. Low precipitation, fewer snowfall events and increased temperatures resulting in lengthier and severe droughts. Furthermore, depleting water resources, less productivity of agriculture and rangelands are the major issues. Agriculture is the main source of income in rural communities, it's not sustainable due to inefficient use of GW. The rangelands are overstocked, depleted and have low productivity. For the poverty eradication livestock and rangelands are important for rural communities. The GW is depleted because of over-exploitation, increase in population and by inefficient irrigation and agriculture. The poor planning, mismanagement, and overexploitation of natural resources substantially reduced the natural recharge of aquifers. Among other causes are, the lack of watershed management activities in the catchment areas and residential societies in potential water recharge areas. The IUCN reflected mismanagement of natural resources in the Integrated District Development Vision Balochistan, [21]. The major causes of mismanagement of natural resources are arranged in box 21.

Box 21. Causes of Mismanagement of Natural Resources; modified after IUCN, [21].

1. Inappropriate subsidy on the power supply and reduced recharge due to de-vegetation and land use in potential water recharge areas.
2. Depleted, overgrazed and low-productive rangelands and livestock due to negligence
3. The decline in wildlife population, ecosystems habitats, deforestation, degradation, and overexploitation of vegetation
4. The poverty of communities related to natural resources
5. Little funding for livestock, rangelands, agriculture, wildlife, forests & protected areas
6. Inefficient utilization of water, gas, electricity, and firewood

4.3 Improvement of GW Resources

The management of GW is a multifaceted association between communities, environment, integrated watershed management and the relevant SAP's. The overexploitation of environment and natural resources are among the major causes of GW depletion. The options for improvement include; watershed management, community participation, increasing rainwater harvesting, GW recharge, efficient irrigation systems, and water governance. In some of the previous studies, certain measures have been proposed for the improvement of water resources, which included an Integrated District Development Plan; IUCN, [22]. The outcome of the studies carried out by IUCN for the improvement of water resources is presented in Box 21, [22]. A firsthand water resources management strategy can be attained by the combination of the major causes of mismanagement of natural resources as outlined in Box 20, and the study's outcome for the improvement of water resources outlined in box 22.

Box 22. Studies Outcome for Improvement of Water Resources, [22].

1. Water loss reduction and leakage control of supply
2. A complete ban on agriculture tubewells in urban areas
3. Recycled wastewater in urban areas to farmers
4. Construction of DADs, storage and supply dams
5. Development of new water resources and recharge measures
6. Environmental Improvement Project for drinking water
7. Effective monitoring and metering of the system
8. Construct wastewater recycling plants to irrigate land
9. Drainage system's rehabilitation

5. Integrated Watershed Management Strategy

The Balochistan Plateau is comprised of 18 river basins that are divided into 73 sub-basins, numerous watersheds, and many-more subwatersheds. The river basins encompassed drainage areas from 1,115 Km² of Kand River to 84,916 Km² of Hamun-e-Lora. It's challenging and occasionally impossible to manage a river basin of 84,916 Km² in an arid climate with little resources. The subwatersheds require

exceptional management scopes and needs, planning issues, priorities from monitoring to data collection and implementation. The integrated watershed management is a process to manage human activities and natural resources on a watershed basis. Further, to consider social, economic and environmental issues, and community interests to manage water resources sustainably, [30].

To protect and conserve natural resources the Integrated Watershed Management Strategy (IWMS) is developed. The IWMS is prepared with the critical assessment of the twenty SAPs related to federal and provincial governments. The twenty SAPs are revised, enhanced, reformed and presented in the boxes from 1-22. For the sustainable development of water resources appropriate planning, management, conservation and protection measures have been proposed in the subsectors. The IWMS is a flexible yet comprehensive strategy that may be updated anytime whenever additional data are available. The updates and modification can be made with the mutual discussion, consultation and participation of the concerned government agencies, water experts, NGOs, representatives of the civil society and end beneficiary communities. The strategy comprised of five leading sectors with 27 subsectors to conserve natural resource relevant to surface and GW management and is presented in box 23.

The water governance is a multi-level participation process beyond the government, where the decision is made by public institutions, civil society, the private sector, and by the communities. It encircles the relationships between governments and societies, including laws, regulations, institutions, and interactions that affect the ways in which governance systems function, [31]. The principles of water governance are imperative for the implementation of effective policies. The policies help for responsible groundwater use, equity, sustainability, and efficiency. In this background, the establishment of the Balochistan Water Board, Balochistan Water Resources Management Agency and upgrading the Bureau of Water Resources are recommended.

The environmental concerns are related to global warming and climate change. Appropriate policies and measures are required to minimize the effects of weather events of extreme nature such as storms, floods, and droughts. Environmental management is associated with water, air, solid and hazardous waste contamination and pollution. To mitigate the environmental impacts, the strategy ensures water and food security and challenges posed by the climate change. The sustainable rural environment for communities is an important issue to address with an increase in population.

The conservation and sustainable development initiated with institutional research, monitoring, and GIS-based information databases. It is also addressed to the management of urban areas, coastal, marine resources, improve resources security and reduce conflicts, sustainable utilization of water, improve water supply coverage and quality protection.

The natural resource management is related to water, soil, plants, animals and lands. For the successful management of natural resources, the cumulative work of land use planners, water management, biodiversity conservation, and the future sustainability of agriculture, mining, tourism, fisheries, and forestry is imperative. It's important to improve the water quality of rivers, water bodies and GW through legislation and laws. The management is imperative to control deforestation, halt desertification, management of protected areas and ecological corridors, and sustainable water flows. The social and economic awareness of GW management, conservation, and resource allocation is also an integral component of resource management.

The community empowerment is an effort to create a partnership between government and communities with an emphasis to improve the welfare of rural communities. It is to empower individual communities to achieve desired results to improve their quality of life and living standard. The communities identified their problems and probable solutions with the support of the government departments. The NGO's, individual experts, businesses and developmental agencies work collaboratively with communities to solve their problems. All rural development programs would be identified by individual communities and implement by the best means for attaining the set goals of development. In this regard, the empowering legislation will encourage communities for collaborative efforts for the betterment of the entire community in all aspects.

Box 23. Integrated Watershed Management Strategy; compiled by the authors.

Water Governance:

1. Balochistan Water Board; establish to formulate policies and rules
2. Balochistan Water Resources Management Agency; upgrading Bureau of Water Resources
3. District Water Committees; strengthen to implement policies at district level

Environmental Concerns:

4. Water, air, solid and hazardous waste pollution management
5. Integrating population, gender, poverty, health, trade and environmental programs
6. Mitigating impact of global warming and climate change, such as floods, droughts & storms
7. Sustaining an environment-friendly development and provide environmental education
8. Improve water quality of rivers, water bodies and GW through legislation and laws

Conservation and Sustainable Development:

9. Improve institutional research, monitoring, GIS-based information databases & coordinators
10. Management of urban areas, coastal, marine resources, improves security & reduce conflicts
11. Sustainable utilization of water; improve water supply coverage and quality protection
12. Better conditions of equity for irrigation, urban and rural domestic water
13. Sustainable agriculture, agrobiodiversity, production, consumption, efficiency and demand
14. Water vision, sustainable withdrawal, conservation, management and productivity
15. Improve data collection network, water management, conservation, construction of DADs

Natural Resource Management:

16. Ecosystem rehabilitation for biodiversity conservation, wildlife habitats, flora and fauna
17. Biodiversity protection and conservation; gender, poverty and biodiversity nexus
18. Rehabilitation terrestrial, inland wetland, coastal ecosystems
19. Controlling deforestation, establishing protected areas and ecological corridors
20. Conserving, rehabilitating, developing, forests sustainably, scientific planning and research
21. Re-vegetation rangelands, halt desertification for sustainable water flow & livestock
22. Afforestation, harnessing flood and rainwater through efficient conservation in watersheds
23. Management of watersheds for sustainability of surface and GW

Community Empowerment:

24. Empowering communities for self-sustaining, social awareness and women's participation
 25. Improving physical infrastructure of communities in tune ecosystem of surrounding area
 26. Community understanding of water issues, eradicate poverty dependent on natural resources
 27. Promote IWMS principles, demand assessment, development, monitoring and cost recovery
-

To support the IWMS a conceptual strategic model is prepared. The model represents the flow of major activities and their linkages with each-other as well as subsectors. The model is the outcome of a systematic and methodological analysis of IWMS, and related SAPs. The conceptual model provides an association from water governances to community empowerment.

The water governance is the prime body to oversee and regulate the water management activities in the province from the top level. It is encircled all agencies related to natural resources, all water-related issues, and activities from policy to implementation through communities. The water governance will also oversee the work of all government agencies related to water management and conservation.

The individual government departments will prepare SAPs with the consultation of all stakeholders for the sustainable management of natural resources. The concerned agencies also implement relevant SAPs and other activities with the coordination and assistance of rural communities. The sustainable socioeconomic development of the rural communities would be the focal point of the strategies. All field activities demonstrated would be carried out in consultation and ownership of the concerned communities. IWMS model compiled by authors is presented in figure 2.

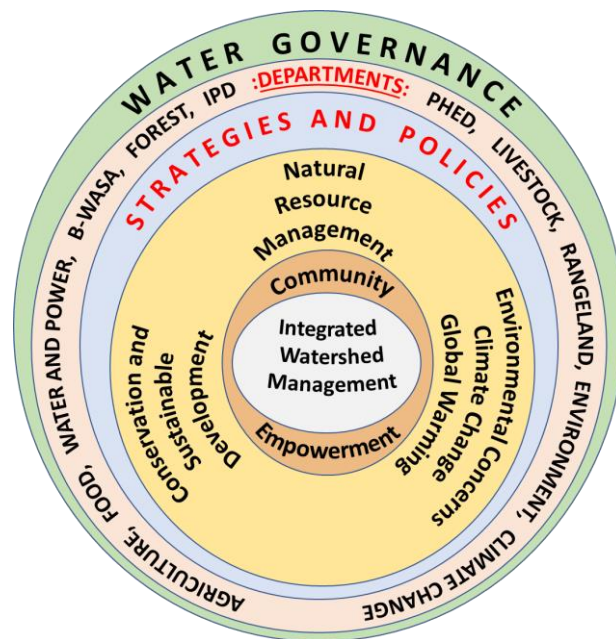


Figure 2.
Conceptual Model,
Integrated Watershed
Management Strategy.

6. Conclusions

In most parts of Balochistan plateau, the GW levels are declining due to increased abstraction through subsidized electrically powered and solar pumps. The GW is easily accessible in larger capacities and from greater depths by improved drilling techniques. The decline has been focused in irrigated areas of semiarid and arid regions. In arid areas, the present GW recharge is negligible in comparison with extraction. Consequently, the ongoing decline in GW storage is bound to cause deterioration of the GW dependent ecosystem and depletion of surface water resources. It also deteriorates GW quality, causes land subsidence and forces rural populations to migrate to urban centers.

To manage aquifer recharge, the conservation and utilization of available surface water resources wisely and efficiently along-with harness of flood and rainwater. The GW demand can be managed by modern irrigation techniques, low delta crops, water conservation strategies and policies, and higher pricing of electricity and water supply metering. The other factors are hydrogeological investigations, resource assessment, monitoring, resource allocations with community consultation and farmer-led GW management.

The IWMS is prepared with the assessment, analyses and summing up the twenty SAPs related to federal and provincial governments. The strategy comprised of five leading sectors and twenty-seven subsectors relevant to surface and GW resources. The leading sectors are; water governance, environmental concerns, conservation and sustainable development, natural resource management and the community empowerment.

For the sustainable development of water resources appropriate planning, management, conservation and protection measures have been proposed for the subsectors. The IWMS is a flexible yet comprehensive strategy that may be updated anytime with the consultation of all the stakeholders.

To support the watershed management policy a comprehensive strategic model is prepared. The model represents the flow of major activities and their linkages with each-other as well as subsectors. The model is the outcome of a systematic and methodological analysis of IWMS, and related SAPs and provides links between water governances to community empowerment.

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