

State Level Workshop on “Ground Water Management in Uttar Pradesh
—Challenges, Priorities & Strategies”, August 20-21, 2009, Lucknow

**SWaRA RESOLUTION
FOR
GROUND WATER MANAGEMENT IN UTTAR PRADESH**

“Recommendations & Strategies for Action”



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CONTENTS

	Title	Page No.
1.	Background	1
2.	The Objective	2
3.	Workshop Proceedings & Deliberations	2
4.	Major issues deliberated in the workshop	6
5.	Recommendations & Strategies for Action	7
◆	Ground Water Planning	7
◆	Basin/Watershed approach for Ground Water Management	9
◆	Ground Water Budgeting/ Assessment	10
◆	Aquifer Mapping & its management	11
◆	Ground Water Management in stressed/problem areas:	11
◆	Ground water conservation	13
◆	Conjunctive use management	15
◆	Ground Water Quality	16
◆	Data collection and Dissemination	17
◆	Information, Education and Communication	18
◆	Research and Pilot Studies	19
6.	Inputs Acknowledged	20

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BACK GROUND

*The haphazard development of ground water in the state of U.P. has led to over-exploitation resulting into depletion of ground water regime & scarcity in resource availability, while due to improper irrigation practices in canal commands, problem of rising water levels & water logging has emerged in some areas of the state, whereas deterioration of ground water quality is also an issue of concern. Because of such situations, the issues of **Ground Water Management & its Governance** have come to the forefront. Unless, appropriate ground water management policy & efficient strategies, (supported by suitable regulation and, economic & administrative systems) are brought into implementation, ground water related problems will continue to rise in the state.*

Realizing the need & urgency of managing ground water resources in U.P. in a sustainable & integrated way, the State Water Resources Agency i.e. SWaRA, an Apex Institution of Water resources Sector in the state of U.P., has therefore organized a two-day State level Workshop on “Ground Water Management in Uttar Pradesh-Challenges, Priorities & Strategies” on August 20-21, 2009 at Lucknow, U.P.

In the background of this workshop, it is relevant to mention that though ground water resource has attained a vital position in the overall water-resource development plans & programmes of the state but on the other side, it is also important to mention that ground water is one of the most neglected, unregulated, indiscriminately exploited and non-conjunctively utilized natural resource in the state.

- The issue is obviously the poor management of ground water resources in our state. The diversified ground water problems viz. depleting aquifers, water level lowering and also ground water quality concerns, rising water levels vis-a-vis water logging have posed several challenges. And, these are the prime reasons why the issue of ground water management & its governance has come to the forefront.
- This two-day workshop was primarily organized to identify & evaluate different ground water related problems & issues in the state, to find the possible gaps in

resource management process and to have experiences of various water related departments & organizations in identifying the management priorities, so that concrete recommendations and some useful action plans for managing ground water resources in U.P. could be suitably documented as “SWaRA Resolution for Ground Water Management in Uttar Pradesh”. This document will certainly be helpful in formulating appropriate and action-oriented practical ground water management policies & long-term strategies for the state with effective interventions.

2. THE OBJECTIVE

- > “Sustainable management of ground water resource in the state of U.P. should be envisaged through conservation & protection of aquifers ensuring regulated extraction & judicious development of ground water and minimizing its wastage & controlled utilisation in problem areas of the state by initiating conjunctive use applications & adopting concept of Integrated Water Resources Management (IWRM), wherein, IWRM, an interdisciplinary & multi sectoral concept, is based on perception of water as an integral part of ecosystem, a natural resource & economic good.

- > **Management Goals for Ground water resources in the state of U.P. shall be:**
 - To fix allowable withdrawals based on sustain use of aquifers for irrigation, domestic & industrial water supplies as well as for the ecological needs.
 - To integrate ground water quantity and quality in decision making.
 - Focused attention to overexploited/critical areas (Urban stressed & Rural stressed Areas).
 - To practice Rain water Harvesting and Aquifer Recharging.
 - To adopt Conjunctive use management of surface and ground water.
 - Deepening & rejuvenation of wells and protecting water bodies.

3. WORKSHOP PROCEEDINGS & DELIBERATIONS

The State level Workshop on ‘Ground Water Management in U.P.’, organised on August 20-21, 2009 at Lucknow, was a successful event, with marked participation from almost all water related Central & State level Government departments, NGOs, consultants . About 200 delegates participated in the two day deliberations.

Various thought-provoking and informative deliberations on different aspects of ground water have come-up during the workshop. Overall five Technical Sessions have been conducted and almost all the issues, pertaining to ground water situations & problems in the state of Uttar

Pradesh, were covered & discussed by the invited speakers representing different departments, institutions & organisations working in the field of water resources. A Special Session on the prospects of 'Storm Water Run-off Conservation' in the state was also taken-up. Besides, an exhaustive Panel Session for formulation of Recommendations aimed to prepare 'SWaRA Resolution for Ground Water Management in U.P.,' has also been conducted.

The topics in different technical session covered by the speaker are briefed as follows-

➤ **TECHNICAL SESSION-1: GROUND WATER SITUATION IN U.P. & RELATED ISSUES.**

Chairman- Sri Prakash Singh,
Former Director, Ground Water Department, U.P.

Co-Chairman- Sri A.K. Arora
Director, Ground Water Department, U.P.

1. The Crisis of Governance in Ground Water Management: A perpetual threat to Ground Water Stressed Urban Agglomerates of U.P.

Sri B.B. Trivedi, Scientist D, CGWB, Lucknow

2. Significance of Aquifer mapping & lithological framework for sustainable development & management of Ground Water in U.P.

Prof. Rajiv Sinha, I.I.T., Kanpur

3. Status of Drinking Water Supply in Uttar Pradesh.

Sri R.M. Tripathi, Joint Director, U.P. Jal Nigam

SPECIAL SESSION: PROSPECTS OF STORM WATER RUN-OFF CONSERVATION

Chairman- Sri. Sumant Gupta
Dy. Director General, GSI (NR)

Co-Chairman- Prof. Rajiv Sinha,
IIT, Kanpur

1. Trends in Rainfall Pattern over Ghagra-Gomti Basin.

Sri K.P. Singh, Hydrologist, SWaRDAC, U.P.

2. Open Discussion to evolve modalities & prospects for conserving Storm water Run-off / Flood water as Surface/Ground water Storage.

Co-ordinator: *Sri P.K. Srivastava, BPE, SWaRA*

➤ **TECHNICAL SESSION-2: WATER-LOGGING, CONJUNCTIVE USE OF GROUND WATER & SURFACE WATER**

Chairman- Dr. A.N. Singh,
Former Director, Remote Sensing Application Centre, U.P.

Co-Chairman: Ms. Mridula Singh
Additional Director, Land Use Board, U.P.

1. Integrated water resource management in Canal commands by application of Decision Support System.

Sri P.K. Srivastava, Basin Planning Expert, SWaRA, U.P.

2. Interventions for Conjunctive management of Surface & Ground Water in Basin planning.

Dr. Ashok Raut, Team Leader, SMEC Ltd, Australia

3. Remote sensing & GIS based mapping of Water logged and Salt affected lands in Uttar Pradesh.

Sri Rajeeva Mohan, Remote Sensing Expert, SWaRDAC, U.P.

4. Area specific changes in Cropping pattern for Ground water Over-Stressed and Water-logged area and scope of sprinkler/drip irrigation as promising alternatives

Sri L.B.Singh, Joint Director, Agriculture Deptt, U.P.

➤ **TECHNICAL SESSION- 3: GROUND WATER RECHARGE AND CONSERVATION**

Chairman- Sri O.P. Pal

Former Regional Director, CGWB, Lucknow

Co-Chairman- Sri V. Sharma

Former Regional Director, CGWB, Lucknow

1. Effective management options in Over Exploited / Ground water Stress Areas-Rural perspective

Mr.Upendra Srivastava, Scientist-C, CGWB

2. Ground Water Recharging in U.P.: Initiative, Challenges & Strategies

Mr. C. Anant Rao, Hydrologist, Ground Water Department, U.P
& Sri R.S.Sinha, Ground Water Expert, SWaRDAC, U.P.

3. Isotopes in Ground Water Recharge Studies in U.P.

Dr. Bhishm Kumar, NIH, Roorkee

➤ **TECHNICAL SESSION -4: GROUND WATER QUALITY RELATED ISSUES**

Chairman- Sri K.P.Singh

Hydrologist, SWaRDAC, U.P.

Co-Chairman- Dr. Raj Mohan Singh

Asst.Professor, NIT, Allahabad

1. Development of Water quality index for drinking water: an attempt to identify keys for Ground Water Quality Management Framework in U.P.

Dr. Alpana Srivastava, Economist, SWaRA, U.P.

2. Surveillance mechanism of water quality in Ghaghra-Gomti Basin: An Overview

Dr. Seema Srivastava, Environmental Expert, PACT

4. Scenario of Ground Water Quality in Uttar Pradesh.

Sri Amit Mehrotra, UNICEF, Lucknow

4. **Effective Mechanism for Surveillance, Monitoring and Mitigation of Ground Water**

Sri Amit Jain, IRG Systems South Asia Pvt. Ltd.

➤ **TECHNICAL SESSION -5: GROUND WATER GOVERNANCE, LEGAL FRAMEWORK & MANAGEMENT ISSUES**

Chairman- Dr. S.K.Sharma

Former Member, CGWB

Co-Chairman: Sri S.P.Kureel

Chief Engineer, U.P. Jal Nigam

1. **Ground Water Quality Management: The Emerging Challenges and Options with special reference to Uttar Pradesh.**

Dr. N.C.Ghosh, National Institute Of Hydrology, Roorkee

2. **Key socio-economic and administrative trends in Ground water Irrigation, U.P.**

Dr. Niranjana Pant, Sociologist, Lucknow

3. **Legal & Institutional framework for Ground Water Management–status & issues.**

Sri P.R. Chaurasiya, Project Director, Minor Irrigation, U.P.

4. **Rural & Urban communities and Strategies for their productive involvement in Ground water management.**

Sri Aditya Vidya Sagar, Consultant, Lucknow

5. **Ground Water management & conservation in industrial sector**

Sri Anil Shukla, Director, Confederation of Indian Industry.

5. **Ground Water is Grounded?**

Dr. Pradeep K. Srivastava, CDRI, Lucknow

7. **Prospects of Ground Water Potential in Behta nadi basin- As promising alternative for augmenting Lucknow city water supplies**

Dr. M.Singh, Reader, Geology Deptt, Lucknow University.

8. **Water Crisis --a crisis of governance & not of water scarcity**

Sri Johnson Jeyaseelan, Water Aid.

Panel Session for Formulation of Recommendations/ SWaRA Resolution

Chairman: Sri A.S.Dhingra, MME Expert, SWaRA

Panelists

Dr. S.K.Sharma, Advisor (GW), MoWR

Dr. D.K.Gupta, Former E-in-C, ID, UP

Dr. N.C.Ghosh, NIH, Roorkee

Sri Prakash Singh, Former Director, GWD, UP

Sri V.K.Joshi, Former Director, GSI

Sri V.K.Bansal, Eng-in-Chief, ID, UP

Dr. Bhishm Kumar, NIH, Roorkee

Dr. O.P. Dubey, Director, WALMI

Sri Aditya Vidya Sagar, Consultant

(Co-ordinators: Dr. V.P.Singh, PACT & Sri BB Trivedi, CGWB)

4. MAJOR ISSUES DELIBERATED IN THE WORKSHOP

The important ground water issues and respective management options, discussed & deliberated during the two-day workshop for evolving a sustainable ground water management mechanism in the state of U.P., are being given as follows-

- Probable strategies for Ground Water Management in U.P.
- Crisis of governance in Ground Water Management of Stressed Urban sprawls.
- Effective management options in Over-exploited/Ground water Stressed Rural areas.
- Option of Canals as a major source of recharge for transforming depleted ground water areas.
- Initiative for Aquifer Mapping & Lithological framework for sustainable development & management of Ground Water Resources in different hydrogeological set-ups of U.P.
- Watershed based approach for Ground water conservation in Bundelkhand.
- Drinking water supply scenario in U.P and challenges of potable supplies.
- Prospects of promising alternatives for augmenting Urban water supplies through periurban aquifers and surface water resources.
- Policy initiatives & interventions required for Conjunctive use management of Surface & Ground water in Basin Planning.
- Prospects of Deep exploration in alluvial plain of Ganga basin in U.P.
- Importance of Integrated Water Resource Management (IWRM) in canal commands by applying Decision Support System.
- Water saving cultivation practices through Area specific changes in existing cropping pattern/ crops for Overstressed and Water- logged areas.
- Scope of Sprinkler/Drip irrigation practices in stressed areas, as promising alternatives.
- Initiatives, challenges & scope of Rain Water Harvesting & Ground Water Recharge in U.P.
- Importance of Isotopes in Ground Water Recharge and resource estimation studies.
- Scenario of Ground Water Quality in U.P and emerging trends of ground water pollution & causes.
- Challenges & options for Ground Water Quality Management in U.P.
- Importance of Water Quality Index and identification of keys for development of Ground Water Quality Framework in U.P.
- Status of Surveillance mechanism of Ground Water Quality.
- Social, economic & administrative trends effecting Ground Water Irrigation in U.P.

- Status of legal & Institutional framework and related Issues for Ground water Management in U.P.
- Water crisis – and issue of governance and management in U.P.
- Ground water management practices & different scenarios in Industrial sector.
- Productive involvement of Rural & Urban Communities & Role of I.E.C. in Ground Water Management.
- Sciencetoon (science cartoons)-as a potential communication tool for creating awareness in masses.

5. RECOMMENDATIONS & STRATEGIES FOR ACTION

The state of Uttar Pradesh, characterized by varied hydrogeological situations, is presently facing diversified ground water problems, which led to almost imminent threats in certain areas of the state as far as ecological protection of ground water resource is concerned.

So, the immediate challenge is to effectively manage ground water resources of the state in a holistic manner. Therefore, co-ordinated efforts of all major ground water players, both at government & non-government levels, are needed to evolve & initiate a sustainable & comprehensive “Ground Water Resource Management Process” (GWRMP) in the state for understanding the-

- Dynamics of ground water system under different hydrogeological setup,
- Interaction between ground water & surface water,
- Quality of ground water & its environmental effects.

5.1 Ground Water Planning:

- ♦ **As, Ground water can not be treated as an isolated resource and hence, integrated/conjunctive planning for ground water and surface water resources including the rainfall component is essentially required in the state of U.P. and accordingly separate planning process must be evolved for Eastern, Central, Western and Bundelkhand regions within a definite time frame.**

- a. The extensive data for ground water aquifers is an important requisite for the planning and management process and to have **basic understanding of confined (deep) and unconfined aquifers in urban and rural segments.** Therefore, it is significant to carryout detailed aquifer mapping involving hydrogeomorphic mapping & sub-surface lithostratigraphy through well logs and geophysical findings.

- b. **Hydrogeological research** and applications are needed to yield information on the concurrence and dynamics of ground water system as a contributing factor in water resource management.
- c. There should be **policy framework for using ground water from deeper aquifers** after due rethinking and framing economic extraction limits that would not damage the aquifers.
- d. There should be specific guidelines for ground water **withdrawals from urban aquifers**.
- e. For sustainable water supply needs, shallow aquifer zones should be separately managed from deeper aquifers in the areas of high exploitation.
- f. Trends of over-exploitation of aquifer particularly in western U.P. have been observed, urgent steps are therefore needed **to enhance recharge of aquifers** through rain water harvesting along with measures to promote water use efficiency.
- g. **Institutional mechanism** is needed to be developed for effective implementation of conjunctive use management process of surface and ground water in commands areas as well as in those urban areas where ground water quality is a problem.
- h. **The capacity building** of government and civil society for sustainable development and management of ground water has become an inescapable necessity. The objective is to enhance and utilize skills and capabilities of people, institutions and various levels to achieve sustainable development through joining of partners.
- i. There is need for inter-agency and inter-sectoral **coordination** of ground water programmes in Uttar Pradesh to take place at various organizational levels.
- j. There should be **regular interactions** between state level organisations like Ground Water Department, Minor Irrigation Department, Agriculture Department, SWaRA, Irrigation Department, U.P. Jal Nigam, Land Development & Water Resources Department, Housing Department, Forest Department, U.P. Pollution Control Board, Remote Sensing Application Centre and Central agencies like Central Ground Water Board, Geological Survey of India, Central Pollution Control Board, Central Water Commission, Indian Institute of Toxicological Research Institute, NABARD, NIH Roorkee, IIT Kanpur & Varanasi, Agriculture & other Universities, and also agencies like UNICEF & Water Aid.
- k. Establish priority **“Ground Water Management Areas” (GWMA)**. These are areas that are **experiencing or expected to experience** in near future critical ground water problems resulting from ground water under mining, contamination of ground water reservoir and/or water logging problem due to high water table.

- l. Formulation & enforcement of **Ground Water Act** should be the topmost priority to effectively manage & regulate the ground water resources and control its indiscriminate exploitation in the state. Provisions **to manage ground water pollution/contaminated aquifers, water-logging & conjunctive use** should also be incorporated in the proposed legal instrument.
- m. Every village must be encouraged, and accordingly supported, to make its **Water Security plan** keeping in mind the drinking and domestic water needs of human and livestock population in long-term.
- n. Central Government Schemes like NREGA may be utilized to create and sustain water conservation schemes. Such schemes may be decentralized, with adequately resourced community participation and ownership, and support in the form of technical assistance from Irrigation Department, Ground Water Department, Minor Irrigation Department and SWaRA.

5.2 River Basin/Watershed Approach for Ground Water Resources Management & Planning:

- > **River Basin/Watershed** approach is the need of hour.
- > All the ground water related studies/activities should therefore be initiated basin/watershed wise in the state.
 - There are 07 Major river basins identified in the state of U.P., therefore it is recommended that the assessment, management planning, development, utilisation & conservation processes for ground water resources, including demarcation of hydrogeological/geomorphic characteristics, alongwith aquifer mapping should essentially be carried out **by adopting river basins/sub-basin approach for Alluvial Region** and **watershed/micro-watershed approach** for hard rock terrain of **Bundelkhand-Vindhyans**.
 - IWRM & conjunctive use planning should be the integral part of River Basin Planning.
 - For the administrative as well as decision-making purposes, in the river basin/watershed planning-process, ground water related informations/GIS layers of district/blocks & urban sprawls should be superimposed within the basin/watershed boundaries.
 - For overall planning of River Basins of U.P., **Indian Standard Guidelines** for ground water component, framed by BIS, March, 1991 should be taken care of.

5.3 Ground Water Resources Budgeting/ Assessment:

> In order to have **refinement in the existing methodology**, the recommendations of the **“Report of the Group for suggesting New & Alternate methods of Ground Water Resources Assessment”** October, 2009, and the Protocol, suggested therein should be adopted on priority basis:-

- The state level Ground Water Estimation Committee, headed by Principal Secretary/Secretary, Ground Water Department, Govt. of U.P. with members from CGWB, Ground Water , Irrigation, Agriculture, Minor Irrigation, U.P. Jal Nigam, Command Areas shall take steps to refine the existing methodology with incorporation of useful methods as suggested by the Central Group SWaRA, Housing department & Rural Development department should also be nominated as member in the state level committee for better interaction & inputs.
- As recommended in the report, **Ground Water Resources Assessment Cell in GWD, U.P.** with dedicated manpower should be established on priority basis to take-up the assigned tasks.
- Field Validation of various parameters viz. Specific yield,, Base flow, unit draft should essentially be taken-up for realistic estimation.
- Remote Sensing application & Tracer techniques should be incorporated to refine the existing norms of assessment with better inputs by delineating the Aquifer Recharge Zones and ground water movement as well as recharge/seepage rate under different conditions.
- Interaction of ground water & surface water flows within hydrogeologic/basin boundaries should be studied, particularly in canal commands.

> **Initiate Urban Ground Water Assessment:**

The GEC-97 norms may quite well be applicable only for the rural-agricultural areas.

- The Horizontal Flow for the urban areas has to be treated differently. Thus, the role of Horizontal Flow in determining the resource may be quite significant.
- All the urban features render the GEC-97 norms unsuitable for computing the Horizontal flow.
- There are 630 Urban local bodies, where ground water is being extensively exploited for **drinking water supplies and aquifers are being depleted heavily.**

Separate methodology/norms for ‘Urban Ground Water Assessment’ should be formulated on priority basis.

5.4 Mapping of Aquifer Systems and Aquifer Management:

- > Uttar Pradesh is characterized by diversified hydrogeological situations, so **mapping of aquifer systems** is of utmost importance for proper assessment & evaluation of ground water resources and to **prepare Aquifer Management Plans** for different areas.
- > **The extensive data for ground water aquifers is an important requisite for the planning and management process** including management of ground water extraction & artificial recharge and also to have basic understanding of aquifer geometry in both rural & urban segments of the state.

It is therefore recommended:

- Detailed 3-D Aquifer Mapping envisaging hydrogeomorphic mapping & sub-surface lithostratigraphy delineated through well-logs/bore-well data and Geophysical methods should be carried out separately for Alluvial and Bundelkhand- Vindhyan, as aquifer geometry differs significantly from area to area, depending upon the local hydrogeological/geomorphological settings.

(3-D Aquifer Mapping refers to collection and collation of subsurface lithological information in terms of vertical & horizontal extension/disposition and water bearing properties including quality of formation water especially salinity.)

- As a first step, a **State Inventory** of all available litho-logs, geophysical survey findings, well-logging results etc. should be developed so as to prepare **Micro level Aquifer Maps**/Aquifer geometry for the planning process.
- For demarcation of **Regional Aquifer System**, aquifer mapping at basin/sub-basin level should be taken –up.
- Gaps related to aquifer data should be identified to generate sub-surface lithostratigraphy coupled with geomorphic data through appropriate methods in a phased manner.
- For managing ground water resource more judiciously & to formulate a sustainable ground water development plan, management of Aquifer System based on a proper Hydrogeological frame work has now become an imperative need. Hence, an **Aquifer Management Authority** is required to be established in the state as envisaged in the Action Points identified for State Water Mission.

5.5 Ground Water Management in Stressed/Problem Areas:

- Separate management goals for Stressed rural and urban areas (where ground water is either being extensively exploited or water levels are continually declining) should be framed.

- Mechanism should be evolved to **periodically review ground water situations in stressed areas.**
- Simple & **usable Ground Water Maps showing critical zones** of water levels decline, over-exploitation within the stressed blocks should be prepared regularly to make the local people, user departments & the administration apprise of the alarming situations.
- In the Shallow Water Level areas, **maps of critically water logged locations** should also be prepared & made available to the concerned departments.
- Scientific studies/monitoring for **water logging/problem of shallow water level**, affecting the agricultural productivity, especially in eastern U.P., should also be given due place in the planning & management process of ground water resources.
- Sincere efforts are needed to prepare **problem specific Micro-Plans** for stressed blocks of western U.P. and for stressed urban sprawls of Lucknow, Kanpur, Agra, Ghaziabad & other similar cities.
- More **effective steps** are required for use of sprinkler and drip irrigation (Micro-Irrigation) in stressed ground water areas.

जल-प्लावित (water-logged) क्षेत्रों हेतु उपयुक्त फसले एवं प्रजातियाँ

फसल वर्ग	फसल एवं प्रजातियाँ
क्षेत्र फसले	धान (मधुकर, जलमग्न, बाढ़ अवरोधी, जलनिधि, जल प्रिया, स्वर्णा सब-1), गेहूँ (एच.डी. 2329), गन्ना, (सी.ओ. 1157 को. से. 96436, यू.पी. 9523), सिंघाड़ा, मखाना
सब्जियाँ	करमुआ, केला
वृक्ष	केला, अमरुद, बेल, टर्मिनेलिया, सहजन, अर्जुन
औषधीय पौधे	लेमन ग्रास, मेन्था, सिट्रोनेला, नागरमोथा, बाहमी, कमल, खरस आदि
चारा	ज्वार
फार्मिंग सिस्टम एप्रोच	मत्स्य पालन के साथ मुर्गी पालन, बतख पालन, बटेर पालन, सूकर पालन, सिंघाड़ा, केला व धान की खेती

भूजल दबावग्रस्त (Ground water stressed) क्षेत्रों हेतु उपयुक्त फसले एवं प्रजातियाँ

फसल वर्ग	फसल एवं प्रजातियाँ
क्षेत्र फसले	धान (नरेन्द्र 97, नरेन्द्र 118, गोबिन्द), मक्का (पूसा कम्पोजिट 3, गंगा 5), गेहूँ (पी.वी.डब्ल्यू 396, पी.बी. डब्ल्यू 373, पी.वी. डब्ल्यू 299, पी.वी.डब्ल्यू 533, एच.डी. 288), सरसों (शेखर, पूसा कल्याणी, वी.एस. 2, वरदान), दलहनी एवं तिलहनी फसले
सब्जियाँ	लोबिया, परवल
वृक्ष	अमरुद, बेर, नींबू वर्गीय फल, कटहल, करौंदा, सहजन, पनियाला, खिरनी
औषधीय पौधे	अश्वगंधा, बेल, आँवला, गुग्गल, सनाय, सतावर, बाय बिडंग, ग्वार पाठा, पामारोजा
चारा	लूसर्न, लोबिया, नेपियर, बाजरा

Strategy for Lucknow City:

- A thoughtful ground water management strategy, covering all practical aspects, is needed for Lucknow city, which is one of the most highly stressed urban agglomerates of the state.
- Besides initiatives for effective conservation, **withdrawal** from the existing tubewells situated within the city **should be restrained** and further exploitation should only be done from **potential peri-urban aquifers** in order to give respite to city's heavily depleted aquifers.
- A strong policy initiative with promising alternatives for controlling ground water withdrawal is urgently required to save & protect the Lucknow's aquifers from further damage.

5.6 Ground Water Conservation:

- > For the success of ground water recharge programme, concept of 'I I I ' i.e. **Initiative, Implementation & Impact** is required to be given due recognition as a promising tool for getting fruitful results.
 - ♦ **Roof top rain water harvesting** should be **promoted only in urban areas**.
 - ♦ It is advisable that in urban areas **Recharge Pit & Recharge Trench methods** should be mostly taken up **to protect aquifers from pollution. Direct injection/recharge well methods should not be encouraged.**
- For rural areas, area-specific **water spreading methods** and on-farm techniques should be largely promoted with adequate participation of farmers.
- **Direct recharging** of aquifers from open paved/unpaved areas should not be encouraged, because of greater risk of pollution, **as already banned by the state government.**
- There are various government orders and guidelines issued for rain water / roof top rain water harvesting, but the implementation and monitoring mechanism is extremely weak. The **bottlenecks in implementation** of rain water harvesting schemes need to be identified and an enabling legal, institutional, technological and economic framework should be developed & executed by the State Ground Water Department (Nodal Agency). But, for achieving such new task, **the department needs comprehensive strengthening.**
- Guidelines for rain water harvesting issued by state Ground water department should be strictly followed.

- A regular inspection schedule of these schemes be made by expert, to check if these are not polluting ground water reservoir.
- Checking of quality of water to be applied for recharging should be ensured.
- To have better results, the recharge/water harvesting structures should be regularly maintained.
- Effective mechanism for **Impact Assessment** of ground water recharge should be evolved in the state to know the techno-economic benefits of recharge programmes.
- Declining **trend of Rainfall** should be taken into consideration, while preparing area specific recharges plans.
- Appropriate mechanism should be developed to utilize and reuse waste water including primary and secondary treated sewage, domestic grey water and industrial effluent. **In any case these should never be allowed to be discharged in any surface on ground water body.**
- Effective steps are required to be undertaken to reduce **unaccounted water losses in urban water supply systems**, particularly **in areas where supply is made from ground water resources.**
- For the **industrial areas**, separate provision are urgently needed for managing & protecting ground water resources/aquifers.
- A rolling programme of **water audit** for all industries should be initiated with compilation of register of industrial water use.
- All **water intensive industries** using ground water should be required to install water meters and undertake geo-scientifically recommended ground water recharge activities.
- The sustainable and socially acceptable cropping pattern for specific area based on the available resource for conjunctive use of surface and ground water, climate and nature of soil in the area, be evolved and encouraged by SWaRA and Agriculture department.

SUGGESTED STRATEGIES FOR BUNDELKHAND

- ♦ Only Micro-watershed based approach be adopted for recharging instead of fragmented methods of executing schemes.
- ♦ Saturate one micro watershed first with small & site specific RWH structure. Objective is to check the high run-off in hard rock areas.
- ♦ A study revealed that 3000 Micro catchments of 0.1 Hect. capture 5 times more water than a single catchment of 300 Hect.
- ♦ In Bundelkhand, RWH in water shed up to 50 Hect. would yield good results.

- ◆ Small rain water harvesting structures should be given priority in Bundelkhand, as this may adequately check excessive run-off & allow more percolation of rain water.

5.7 Conjunctive Use of Surface and Ground Water:

- Sole dependence on ground water needs to be replaced by conjunctive use of ground water and surface water.
 - Basin, sub-basin-wise surface and ground water conjunctive use development plans should be prepared by State Water Resources Agency (SWaRA) with stake holder's participation.
 - Effective policy decisions with suitable provisions are required to be taken at government level **for effectively implementing conjunctive use plans.**
 - Concerned department should be given the responsibility of '**Nodal Agency**' for monitoring the execution of conjunctive use plans.
 - Equitable distribution of canal water among all farmers of the command areas should be of utmost priority. Truthfull implementation of canal rosters and regulations is needed.
 - Precise measurement, control and monitoring of discharges in main branch distributor and minor canals to keep them in accordance with canal roster/regulation orders is required.
 - Strict measures are needed to prevent all illegal water extraction from canal to that authorised water discharges reach to the tail ends of canals. Osrabandi to decide individual share of farmer from the outlet is a must.
 - The farmer shall use his canal water share in conjunction with the ground water for his crops. For better productivity, timely irrigation is a must which can be certainly provided by ground water. It is necessary to sensitize and educate the water users with the adverse impacts of using more than his share (as per Osrabandi) in canal water vis-a-vis the benefits of conjunctive water use for this purpose.
 - For successful implementation of conjunctive use practices, **dual roster for ground water & surface water use should be prepared for execution even at command of minor level.**
 - The **DSS model** developed by SWaRA should be applied in canal commands for balanced use of surface & ground water as well as for sustainability of environment.
- Following measures are required for widespread acceptability of the concept among the water users located in different reaches of canal system :-
 - i. Water Users Associations (WUA) are to be formed on canal systems and should be sensitized and educated for practicing for equitable distribution of canal water as

per Osrabandi and use of water from authorised outlets only and promoting conjunctive use of surface & ground water.

- ii. Disadvantages of using more than their share of canal water in the form of soil degradation, loss of nutrients to adjacent fields and poor productivity vis-à-vis the benefits of optimum irrigation at critical stages of plant growth, flowering & maturity of different crops and consequential rise in quality and quantity of the produce and thus additional net income are to be demonstrated through extension activities and field demonstrations.
- iii. In order to encourage the conjunctive use, equity in cost of irrigation is necessary. The Government has to consider the upward revision of canal irrigation tariff to bring it at par or more with respect to actual cost of ground water irrigation through diesel pump sets with the provision of legal actions.
- iv. Intensification of community, private tube wells should also be encouraged in upper reaches by providing higher subsidies for community boring and pump sets installation for development of an effective vertical drainage -cum-intensive ground water irrigation system.
- v. Secondly, by way of incentive, power supply to the private tube wells located in head / middle reaches of the canal system should be provided to discourage and illegal canal water extraction in head reaches.
- vi. In order to help in mitigating the problem of chronic water locked areas it is recommended to provide financial support to irrigation through ground water alone through solar pumps under non conventional energy development programme.
- vii. Design projects for stabilising declining ground water table areas particularly in western and central U.P. through increased Kharif irrigation canals from surface water and rainwater harvesting, and promoting micro irrigation (sprinkler and drip system) in ground water uses. **In over-exploited district Badaun, such management strategies i.e. construction of large scale kharif channels for increasing extensive recharge should be taken-up on priority to De-stress the area.**

5.8 Ground Water Quality:

- A review of basic ground water quality and analytical public health facilities should be taken up at the district level in collaboration with urban local bodies and State Ground Water Department. A program to improve water analysis capability at the district level should be initiated which should have provision for :

- (i) Monthly, bi-monthly, quarterly, half yearly or yearly monitoring and analysis of ground water quality for critical areas be worked and implemented through a properly designed monitoring network,
- (ii) Institutional arrangements and proper coordination for water quality data sharing and development of data retrieval system,
- (iii) Demarcation of vulnerable ground water quality zones of whole U.P.
- (iv) Delineation of safe deeper aquifers underneath the contaminated aquifers and assessing the scope of their tapping,
- (v) Developing ground water quality thematic maps in GIS-environments,
- (vi) Ground water quality modeling studies to ascertain direction and transport of pollutants in the aquifer system,
- (vii) Deriving scope to tap top-most shallow aquifer by suitable devices like radial collector wells.
- (viii) Undertaking large scale mass awareness campaign and social empowerment programme to enhance knowledgebase about ground water quality/pollution hazards.
- (ix) Consider setting up of “**Ground Water Citizen Advisory Committee**” particularly with regard to quality & health aspects of ground water management.
- (x) Increase surveillance over Nitrate, Pesticides, Arsenic and Fluoride rich ground water areas.
- (xi) Study, measurement and disseminate cheap and easy methods to remove injurious iron, fluoride, arsenic, etc. from ground water at local levels.
- (xii) Ground Water **abstraction from known polluted aquifers should be banned through public notices.**

5.9 Data Collection and Dissemination:

- Practically, the state of U.P. is very rich in ground water data but such data is not available under single umbrella. However, huge data, maps & diversified information on ground water related to U.P. are available with Ground Water Department, Minor Irrigation, U.P. Jal Nigam, CGWB, Remote Sensing Application Centre, Irrigation (Mechanical), Project Corporation, Housing Department, Pollution Control Board, NIH, IITR Universities, IITs and various institutions, but all such data/informations remain un-utilized & lying unnoticed in these organisations due to isolated approach & non-sharing of data and therefore, reliable picture & true scenario of ground water domain of the state could not be evolved so far, affecting the whole planning process. So, an **effective administrative arrangement** should be in place for development of

a **state level Ground Water Data Repository** for analysis, sharing & dissemination for the state's welfare.

- A useful database for general usage may be developed by State Water Resources Data Analysis Centre (SWaRDAC) for dissemination & sharing, which will include hydro-meteorological, hydrologic, ground water level & its availability, water quality, water user, demographic and social data, while adhering to confidentiality.
- Adequacy of basic data station networks should be reviewed by SWaRA and Ground Water Department, whether network of rain gauge/ weather station and bore well / tubewell, piezometers is adequate.
- Instrumentation for data collection throughout the state should be reviewed by SWaRA and State Ground Water Department for reliability, observe resourcing (payment, training and mobility), instrumental efficacy, their protection, timely maintenance and other factors.
- An inter-departmental interactive **Information Sharing System (ISS)** should be developed by SWaRA. This **ISS shall be integrated with a decision support system (DSS)**.
- Protocols should be developed for online data sharing on hydro-meteorological , surface and ground water data with water user associations/ groups and intermediate level local institutions , Panchayati Raj Institutions at block and district level keeping in view Ganga Basin Water Resources Data Security guide line of Government of India. Provision of prompt supply of hard copies on demand at nominal cost should also be made.

5.10 Information, Education and Communication (IEC):

- (i) Information, Education, Communication and adequate capacity building about the ground water management technology must be catered to the urban and rural communities as an integral component of the Water Policy / Act.
- (ii) Educate water operators, water stakeholders, rural and urban home owners and institutions regarding ground water impacts due to various types of landscape amendment practises.
- (iii) Industry segment must take it as its obligation to inform, educate and communicate about the impact of the specific industry on the water levels and its impacts on quality of surface and ground water in the specific area and also that what is the balancing Act being rendered by the particular industry. This particular aspect of the industrial behavior must be an integral section of the water policy / Act.
- (iv) Key recommendations/outcomes of all national workshops organized by any water sector/ sub sector should be **compiled by one nodal agency, preferably SWaRA, for planning and allocation of water.**

- (v) Government needs to initiate large-scale awareness campaign on water conservation in view of natural variation in hydrologic cycle, example **Drought year etc. to avert situation like Bundelkhand in long run.**
- (vi) Communities must also put in their efforts in water conservation at their own levels.
- (vii) Long terms stochastic studies for sustainable water use and measure taken to sustain human and cattle / animal life in a healthy status be made for such frequently drought prone areas.
- (viii) Adopt scientific methods of bore hole abandonment because they form a vertical contamination pathway, and a potential danger for children/animals failing in these.
- (vii) To sensitize the common people and to educate the different users of ground water about its various invisible geo-scientific aspects, an independent state level “**Ground Water Training, Research & Management Institute**” on the lines of Rajiv Gandhi National Ground Water Training & Research Institute **should be created/established in the state.**

5.11 Research And Pilot Studies:

Case studies/ Pilot projects/ Process Documentation / Research and Development programs should be initiated through NGOs, Universities, WALMI and like institutions in the following areas:

- (i) Charging trend in Rainfall pattern and identifying areas of deficient or excessive rainfall.
- (ii) Socio-economic & cultural impacts of over extraction of ground water
- (iii) Assessment of trans boundary aquifers
- (iv) Storm water run-off conservation prospects.
- (v) Impacts due to agricultural, industrial and urban activities on ground water pollution
- (vi) Assess flood water recharge system and Kharif channel irrigation systems for monsoon
- (vii) Integrated development and management of water resources treating rainwater, surface and ground water as unitary resource.
- (viii) Protection of water bodies and their quality
- (ix) Water conservation and augmentation and conjunctive use planning for sustainable urban water supply.
- (x) Impacts of climatic change on water resources.
- (xi) Study of stream-aquifer relationship in river basins to evaluate impacts on base flow, minimum flow of stream and river and river ecology, with respect to ground water development and consequent water table depletion.

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The present document envisages diversified recommendations & suggestions covering almost all the issues related to ground water management & its governance and focusing, in particular, the future management needs for the state of U.P. As the state is presently facing set of multiple problems, this is the high time that we should now act seriously to manage our stressed resource, both in terms of quality & quantity. The efficient implementation of suggested recommendations & strategies may hopefully change & improve the present ground water scenario, which is quite alarming.

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