INTERNATIONAL JOURNAL OF RESEARCH IN COMPUTER APPLICATION & MANAGEMENT

IJRCM

A Monthly Double-Blind Peer Reviewed (Refereed/Juried) Open Access International e-Journal - Included in the International Serial Directories

Indexed & Listed at:

Ulrich's Periodicals Directory ©, ProQuest, U.S.A., EBSCO Publishing, U.S.A., Cabell's Directories of Publishing Opportunities, U.S.A., Google Scholar, Indian Citation Index (ICI), J-Gage, India [link of the same is duly available at Inflibnet of University Grants Commission (U.G.C.)], Index Copernicus Publishers Panel, Poland with IC Value of 5.09 (2012) & number of libraries all around the world.

Circulated all over the world & Google has verified that scholars of more than **5896 Cities** in **193 countries/territories** are visiting our journal on regular basis.

Ground Floor, Building No. 1041-C-1, Devi Bhawan Bazar, JAGADHRI – 135 003, Yamunanagar, Haryana, INDIA

http://ijrcm.org.in/

CONTENTS

CALL FOR MANUSCRIPTS

We invite unpublished novel, original, empirical and high quality research work pertaining to the recent developments & practices in the areas of Computer Science & Applications; Commerce; Business; Finance; Marketing; Human Resource Management; General Management; Banking; Economics; Tourism Administration & Management; Education; Law; Library & Information Science; Defence & Strategic Studies; Electronic Science; Corporate Governance; Industrial Relations; and emerging paradigms in allied subjects like Accounting; Accounting Information Systems; Accounting Theory & Practice; Auditing; Behavioral Accounting; Behavioral Economics; Corporate Finance; Cost Accounting; Econometrics; Economic Development; Economic History; Financial Institutions & Markets; Financial Services; Fiscal Policy; Government & Non Profit Accounting; Industrial Organization; International Economics & Trade; International Finance; Macro Economics; Micro Economics; Rural Economics; Co-operation; Demography: Development Planning; Development Studies; Applied Economics; Development Economics; Business Economics; Monetary Policy; Public Policy Economics; Real Estate; Regional Economics; Political Science; Continuing Education; Labour Welfare; Philosophy; Psychology; Sociology; Tax Accounting; Advertising & Promotion Management; Management Information Systems (MIS); Business Law; Public Responsibility & Ethics; Communication; Direct Marketing; E-Commerce; Global Business; Health Care Administration; Labour Relations & Human Resource Management; Marketing Research; Marketing Theory & Applications; Non-Profit Organizations; Office Administration/Management; Operations Research/Statistics; Organizational Behavior & Theory; Organizational Development; Production/Operations; International Relations; Human Rights & Duties; Public Administration; Population Studies; Purchasing/Materials Management; Retailing; Sales/Selling; Services; Small Business Entrepreneurship; Strategic Management Policy; Technology/Innovation; Tourism & Hospitality; Transportation Distribution; Algorithms; Artificial Intelligence; Compilers & Translation; Computer Aided Design (CAD); Computer Aided Manufacturing; Computer Graphics; Computer Organization & Architecture; Database Structures & Systems; Discrete Structures; Internet; Management Information Systems; Modeling & Simulation; Neural Systems/Neural Networks; Numerical Analysis/Scientific Computing; Object Oriented Programming; Operating Systems; Programming Languages; Robotics; Symbolic & Formal Logic; Web Design and emerging paradigms in allied subjects.

Anybody can submit the **soft copy** of unpublished novel; original; empirical and high quality **research work/manuscript** ***anytime*** in ***M.S. Word format*** after preparing the same as per our **GUIDELINES FOR SUBMISSION**; at our email address i.e. infoijrcm@gmail.com or online by clicking the link **online submission** as given on our website (***FOR ONLINE SUBMISSION, CLICK HERE***).

GUIDELINES FOR SUBMISSION OF MANUSCRIPT

1. **COVERING LETTER FOR SUBMISSION:**

DATED: _____

THE EDITOR

IJRCM

Subject: **SUBMISSION OF MANUSCRIPT IN THE AREA OF _____.**

(e.g. Finance/Mkt./HRM/General Mgt./Engineering/Economics/Computer/IT/ Education/Psychology/Law/Math/other, please specify)

DEAR SIR/MADAM

Please find my submission of manuscript titled '_____' for likely publication in one of your journals.

I hereby affirm that the contents of this manuscript are original. Furthermore, it has neither been published anywhere in any language fully or partly, nor it is under review for publication elsewhere.

I affirm that all the co-authors of this manuscript have seen the submitted version of the manuscript and have agreed to inclusion of their names as co-authors.

Also, if my/our manuscript is accepted, I agree to comply with the formalities as given on the website of the journal. The Journal has discretion to publish our contribution in any of its journals.

NAME OF CORRESPONDING AUTHOR	:
Designation/Post*	:
Institution/College/University with full address & Pin Code	:
Residential address with Pin Code	:
Mobile Number (s) with country ISD code	:
Is WhatsApp or Viber active on your above noted Mobile Number (Yes/No)	:
Landline Number (s) with country ISD code	:
E-mail Address	:
Alternate E-mail Address	:
Nationality	:

* i.e. Alumnus (Male Alumni), Alumna (Female Alumni), Student, Research Scholar (M. Phil), Research Scholar (Ph. D.), JRF, Research Assistant, Assistant Lecturer, Lecturer, Senior Lecturer, Junior Assistant Professor, Assistant Professor, Senior Assistant Professor, Co-ordinator, Reader, Associate Professor, Professor, Head, Vice-Principal, Dy. Director, Principal, Director, Dean, President, Vice Chancellor, Industry Designation **etc**. ***The qualification of author is not acceptable for the purpose***.

NOTES:

a) The whole manuscript has to be in ***ONE MS WORD FILE*** only, which will start from the covering letter, inside the manuscript. ***pdf. version is liable to be rejected without any consideration***.

b) The sender is required to mention the following in the **SUBJECT COLUMN of the mail**:

New Manuscript for Review in the area of (e.g. Finance/Marketing/HRM/General Mgt./Engineering/Economics/Computer/IT/ Education/Psychology/Law/Math/other, please specify)

c) There is no need to give any text in the body of the mail, except the cases where the author wishes to give any **specific message** w.r.t. to the manuscript.

d) The total size of the file containing the manuscript is expected to be below **1000 KB**.

e) Only the **Abstract will not be considered for review** and the author is required to submit the **complete manuscript** in the first instance.

f) ***The journal gives acknowledgement w.r.t. the receipt of every email within twenty-four hours*** and in case of non-receipt of acknowledgment from the journal, w.r.t. the submission of the manuscript, within two days of its submission, the corresponding author is required to demand for the same by sending a separate mail to the journal.

g) The author (s) name or details should not appear anywhere on the body of the manuscript, except on the covering letter and the cover page of the manuscript, in the manner as mentioned in the guidelines.

2. **MANUSCRIPT TITLE:** The title of the paper should be typed in **bold letters**, **centered** and **fully capitalised**.
3. **AUTHOR NAME (S) & AFFILIATIONS:** Author (s) **name**, **designation**, **affiliation** (s), **address**, **mobile/landline number** (s), and **email/alternate email address** should be given underneath the title.
4. **ACKNOWLEDGMENTS:** Acknowledgements can be given to reviewers, guides, funding institutions, etc., if any.
5. **ABSTRACT:** Abstract should be in **fully Italic printing**, ranging between **150** to **300 words**. The abstract must be informative and elucidating the background, aims, methods, results & conclusion in a **SINGLE PARA**. ***Abbreviations must be mentioned in full***.
6. **KEYWORDS:** Abstract must be followed by a list of keywords, subject to the maximum of **five**. These should be arranged in alphabetic order separated by commas and full stop at the end. All words of the keywords, including the first one should be in small letters, except special words e.g. name of the Countries, abbreviations etc.
7. **JEL CODE:** Provide the appropriate Journal of Economic Literature Classification System code (s). JEL codes are available at www.aea-web.org/econlit/jelCodes.php. However, mentioning of JEL Code is not mandatory.
8. **MANUSCRIPT:** Manuscript must be in ***BRITISH ENGLISH*** prepared on a standard A4 size ***PORTRAIT SETTING PAPER***. *It should be free from any errors i.e.* ***grammatical***, ***spelling*** *or* ***punctuation.*** *It must be thoroughly edited at your end*.
9. **HEADINGS:** All the headings must be bold-faced, aligned left and fully capitalised. Leave a blank line before each heading.
10. **SUB-HEADINGS:** All the sub-headings must be bold-faced, aligned left and fully capitalised.
11. **MAIN TEXT:**

THE MAIN TEXT SHOULD FOLLOW THE FOLLOWING SEQUENCE:

INTRODUCTION

REVIEW OF LITERATURE

NEED/IMPORTANCE OF THE STUDY

STATEMENT OF THE PROBLEM

OBJECTIVES

HYPOTHESIS (ES)

RESEARCH METHODOLOGY

RESULTS & DISCUSSION

FINDINGS

RECOMMENDATIONS/SUGGESTIONS

CONCLUSIONS

LIMITATIONS

SCOPE FOR FURTHER RESEARCH

REFERENCES

APPENDIX/ANNEXURE

The manuscript should preferably be in ***2000 to 5000 WORDS***, But the limits can vary depending on the nature of the manuscript.

12. **FIGURES & TABLES:** These should be simple, crystal **CLEAR**, **centered**, **separately numbered** & self-explained, and the **titles must be above the table/figure**. **Sources of data should be mentioned below the table/figure**. *It should be ensured that the tables/figures are referred to from the main text*.

13. **EQUATIONS/FORMULAE:** These should be consecutively numbered in parenthesis, left aligned with equation/formulae number placed at the right. The equation editor provided with standard versions of Microsoft Word may be utilised. If any other equation editor is utilised, author must confirm that these equations may be viewed and edited in versions of Microsoft Office that does not have the editor.

14. **ACRONYMS:** These should not be used in the abstract. The use of acronyms is elsewhere is acceptable. Acronyms should be defined on its first use in each section e.g. Reserve Bank of India (RBI). Acronyms should be redefined on first use in subsequent sections.

15. **REFERENCES:** The list of all references should be alphabetically arranged. ***The author (s) should mention only the actually utilised references in the preparation of manuscript*** and they may follow Harvard Style of Referencing. **Also check to ensure that everything that you are including in the reference section is duly cited in the paper**. The author (s) are supposed to follow the references as per the following:

- All works cited in the text (including sources for tables and figures) should be listed alphabetically.
- Use (**ed.**) for one editor, and (**ed.s)** for multiple editors.
- When listing two or more works by one author, use --- (20xx), such as after Kohl (1997), use --- (2001), etc., in chronologically ascending order.
- Indicate (opening and closing) page numbers for articles in journals and for chapters in books.
- The title of books and journals should be in italic printing. Double quotation marks are used for titles of journal articles, book chapters, dissertations, reports, working papers, unpublished material, etc.
- For titles in a language other than English, provide an English translation in parenthesis.
- ***Headers, footers, endnotes*** *and* ***footnotes*** *should* ***not be used*** *in the document.* However, **you can mention short notes to elucidate some specific point**, which may be placed in number orders before the references.

PLEASE USE THE FOLLOWING FOR STYLE AND PUNCTUATION IN REFERENCES:

BOOKS

- Bowersox, Donald J., Closs, David J., (1996), "Logistical Management." Tata McGraw, Hill, New Delhi.
- Hunker, H.L. and A.J. Wright (1963), "Factors of Industrial Location in Ohio" Ohio State University, Nigeria.

CONTRIBUTIONS TO BOOKS

- Sharma T., Kwatra, G. (2008) Effectiveness of Social Advertising: A Study of Selected Campaigns, Corporate Social Responsibility, Edited by David Crowther & Nicholas Capaldi, Ashgate Research Companion to Corporate Social Responsibility, Chapter 15, pp 287-303.

JOURNAL AND OTHER ARTICLES

- Schemenner, R.W., Huber, J.C. and Cook, R.L. (1987), "Geographic Differences and the Location of New Manufacturing Facilities," Journal of Urban Economics, Vol. 21, No. 1, pp. 83-104.

CONFERENCE PAPERS

- Garg, Sambhav (2011): "Business Ethics" Paper presented at the Annual International Conference for the All India Management Association, New Delhi, India, 19–23

UNPUBLISHED DISSERTATIONS

- Kumar S. (2011): "Customer Value: A Comparative Study of Rural and Urban Customers," Thesis, Kurukshetra University, Kurukshetra.

ONLINE RESOURCES

- Always indicate the date that the source was accessed, as online resources are frequently updated or removed.

WEBSITES

- Garg, Bhavet (2011): Towards a New Gas Policy, Political Weekly, Viewed on January 01, 2012 http://epw.in/user/viewabstract.jsp

CONJUNCTIVE WATER MANAGEMENT: AN OPPORTUNITY FOR INCREASING IRRIGATION EFFICIENCY

Dr. AARTI ARORA
ASSOCIATE PROFESSOR
UNITED INSTITUTE OF MANAGEMENT
NAINI

ABSTRACT

There are a range of settings within which conjunctive use management can occur and there do not appear to be any situations where conjunctive use management should not be practiced. Planned conjunctive use management is far better than spontaneous conjunctive use. Most development has already occurred and no new "Greenfield" irrigation developments are likely at a significant scale. Most implementation of conjunctive use management will be by retro-fitting management arrangements to already existing systems. Poverty reduction in irrigation areas is closely linked to water supply efficiency and hence to conjunctive use management. The regulatory settings for water management for different sovereign States will be the most important setting for management approaches. Any institutional strengthening will need to be supported by strong policy and possible legislative changes. Conjunctive use management will be linked to sovereign policies related to energy, climate change adaption and to food security and hence a broader governmental approach will need to occur. An important part of planned conjunctive use is the identification of the true total cost of water resources and the separate cost to individual users (for example, electricity subsidies are very common). The total real cost and individual water user cost can be very different. The degree of connectivity of surface water and groundwater is an important technical consideration, but not one that will greatly influence whether conjunctive use management is successful. Institutional strengthening around groundwater management and a fully integrated water agency will be a major challenge in most areas. Public education and supporting technical assessments will be an important part of conjunctive use management.

KEYWORDS

conjunctive water management, irrigation efficiency.

JEL CODE

Q15.

INTRODUCTION

Conjunctive use of water relates to the combined use of ground and surface water. Due to the augmented water source, higher water reliability can be achieved. Conjunctive use therefore functions as a buffer for periods of water scarcity. The idea of this management approach is to use surface water when the water table is high and change to groundwater when the water table is low. This technique might be especially important as a buffer function for mitigating impacts of climate change, such as increased heat and drought.

Conjunctive use of groundwater and surface water in an irrigation setting is the process of using water from the two different sources for consumptive purposes. Conjunctive use can refer to the practice at the farm level of sourcing water from both a well and from an irrigation delivery canal, or can refer to a strategic approach at the irrigation command level where surface water and groundwater inputs are centrally managed as an input to irrigation systems. Accordingly, conjunctive use can be characterised as being planned (where it is practiced as a direct result of management intention – generally a top down approach) compared with spontaneous use (where it occurs at a grass roots level – generally a bottom up approach). The significant difference between unplanned and planned conjunctive use, and the approach governance must take to maximise the potential benefits from such use, is explored within this paper. Where both surface and groundwater sources are directly available to the end user, spontaneous conjunctive use usually proliferates, with individuals opportunistically able to make decisions about water sources at the farm scale.

The planned conjunctive use of groundwater and surface water has the potential to offer benefits in terms of economic and social outcomes through significantly increased water use efficiency. At the resource level, groundwater pumping for irrigation used in conjunction with surface water provides benefits that increase the water supply or mitigate undesirable fluctuations in the supply and control shallow water table levels and consequent soil salinity.

The absence of a strategic agenda within governments, and of planners, to capitalise on the potential for planned conjunctive use to support these needs, is generally a significant impediment to meeting national and international objectives as they pertain to food and fibre security. There is an urgent need to maximize production within the context of the sustainable management of groundwater and surface water. The challenges posed by this in some ways reflect the evolution in objectives and management approaches that have been, and remain, common to irrigation development throughout the country. Many existing irrigation commands source their water supply from both the capture of catchment runoff and aquifer systems. Typically, water has been sourced from either surface or groundwater supplies with the primary supply supplemented by the alternative source over time. Accordingly, governance settings, infrastructure provisions and water management arrangements have emphasised the requirements of the primary source of supply, inevitably requiring the "retrofitting" of management approaches onto existing irrigation commands to incorporate supplementary water sources over time. Optimising the management and use of such resources, which have been developed separately will in some situations require substantial investment in capital infrastructure and reform of institutional structures. Put simply, planned conjunctive use is relatively simple with Greenfield (or new development sites), but significantly harder to achieve within existing hydro-physical and institutional/social systems.

Whilst these challenges and the associated benefits of a strategically planned approach are well understood, the current status of water management and planning in India suggests that little has been achieved in its widespread implementation. This paper explores the reasons underpinning the apparent poor approach to full integration in the management and use of both water sources, and the absence of more coordinated planning. It is the authors' view that there remain significant gaps in water managers' understanding as to what aspects of the contemporary management regime require overhaul to achieve integrated management and the improved outcomes that could be expected as compared with separate management arrangements. Such lack of understanding is an important impediment to the governance, institutional and physical infrastructure reforms whereby planned conjunctive use could improve existing management and regulatory arrangements. Reforms may also be impeded by different 'ownership' models of groundwater and surface water delivery infrastructure and the associated entitlement regime (i.e. private and /or public); a situation that has Implications for social and institutional behaviour and ultimately the adoption of a conjunctive management approach.

This paper is intended to provide insight into these barriers to adoption and hence provide a new focus on an old paradigm; a focus intended to make progress with the objective of improved water management and water use efficiency and so support longer term outcomes in the form of improved food security in critical parts of India.

CONCEPTS AND MISCONCEPTIONS OF CONJUNCTIVE USE

In most climates, precipitation, and consequently peak river discharge, occurs during a particular season of the year, whereas crop irrigation water requirements are at their greatest during periods of low rainfall when unregulated stream flows are significantly lower. For many irrigation systems, water supply is aligned with crop water requirements through the construction and management of dams, which capture water during periods of high flow, enabling regulated releases to meet crop water requirements. However, the construction, operation and distribution of water from dams are inherently costly undertakings. Furthermore, dams

and the associated distribution systems are commonly subject to high system losses through evaporation and leakage and they have social and ecological impacts upon communities and the environment in and on which they are built.
Conversely, under natural recharge regimes, groundwater storage requires no infrastructure, the aquifer serving as the natural distribution system. The point of irrigation, in a groundwater-fed irrigation command, is commonly opportunistically located close to the groundwater extraction point, which in turn is integrated into on-farm irrigation infrastructure. Under a sustainable extraction regime, groundwater of a suitable quality can provide a reliable source of water either as a sole supply of water, or to supplement alternative sources. Commonly, the large storage to annual use ratio typical of many regional aquifers means that the reliability of supply from groundwater is less affected by seasonal conditions than are surface water systems, and may indeed provide significant buffering against droughts. However, most intensively used groundwater systems (within the context of irrigation) are located in the semi-arid parts of the world and are characterised by relatively low annual recharge. Then the ratio of annual use to long term annual recharge becomes the predominant measure of sustainability for these systems, independent of aquifer storage. Whilst providing a large storage and natural distribution system, aquifers are, generally speaking, unable to capture a significant portion of runoff arising from large rainfall events. Aquifers therefore do not annually harvest water on a scale that justifies the construction and operation of centralised water delivery systems based on groundwater alone.
The aim of conjunctive use and management is to maximise the benefits arising from the innate characteristics of surface and groundwater water use; characteristics that through planned integration of both water sources, provide complementary and optimal productivity and water use efficiency outcomes.
At the farm scale, conjunctive use is implemented on a day to day basis with 'management' characterised by low level (or micro) decisions incorporating factors such as resource availability, costs of delivery to the crop, tradability of unused allocation and water quality. Collectively, these factors contribute to minimising costs, optimising production and maximising net profitability. However, at the irrigation command level, planned conjunctive water use and management aims for higher level objectives. Planned conjunctive use is expected to optimise productivity and equity in the management of surface water and groundwater resources (World Bank 2006) and promote economic, environmental and social sustainability.
The aquifer provides a natural storage system to source groundwater during periods of demand, Optimal management may take advantage of unutilised storage capacity through Managed Aquifer Recharge (MAR) whereby recharge is enhanced for later recovery. From a conjunctive use perspective, such a management approach enables surplus surface water to be captured (during high flow events) and utilised at times when the dam or stream flow is depleted or when water is required for other purposes. Groundwater recharge enhancement can be via injection down recharge wells, storage of water in infiltration basins or slowing the natural flow of surface waters to induce additional groundwater recharge
An example of this approach is found on the Al Bettina coastal plain of eastern Oman where highly episodic wadi flood flows are captured by dams and the retained water is encouraged to recharge the productive gravel aquifer underlying the area. However, in general, aquifers rarely offer large enough storage capacity for absorbing large volumes of flood water in a short period of time. The use of artificial recharge (or MAR) as a management option couples the attributes of the aquifer system with those of the surface water system without relying upon the natural hydrological regime of the water cycle. In effect, it decouples the need for physical connection between surface water and groundwater resources through engineering interventions. MAR as an adjunct to conjunctive management would in most cases only be likely to occur through coordinated planning which may range from village scale low technology water harvesting approaches, to technically sophisticated approaches (as increasingly being adopted in the developed world). Irrespective of the degree of technical sophistication, the planning requirements associated with a successful MAR initiative are such that it is an aspect of conjunctive management that is unlikely to be adopted where spontaneous 'farm scale' conjunctive use prevails.
At the general level the benefits attributed to optimising conjunctive use of surface and groundwater have been investigated over many years through theoretical modelling and studies of physical systems. These benefits take the form of:
1-Economic gains
2- Increases in productivity
3- Energy savings
4- Increased capacity to irrigate via larger areas
5- Water resource efficiency
6- Infrastructure optimisation
An example includes Bredehoeft and Young (1983), who modelled a twofold increase in net benefit arising from conjunctive management. Another is the Agriculture and Rural Development Group, World Bank (2006), which reported a 26 per cent increase in net farmer income, substantial energy savings, increased irrigation and substantial increase in irrigated crop area for Uttar Pradesh, India, as a result of conjunctive management of monsoon floodwaters in combination with a regional groundwater system.

REQUIRED INSTITUTIONAL STRUCTURES FOR EFFECTIVE CONJUNCTIVE USE MANAGEMENT

Conjunctive use management is not constrained mostly by a lack of technical understanding (though this is an important constraint), but rather by ineffective and incompatible institutional structures, with separate management arrangements almost always established and operated by different institutions. As well, water resources at the sovereign level are often managed by a dedicated agency, whilst irrigation commands are often managed by agricultural agencies or dedicated irrigation command authorities. Overall water resource policy may be set at a jurisdictional scale with the irrigation sector required to operate under the authority of a regulatory agency. This results in a complex mosaic of planning and decision pathways that are not easily overcome in the pursuit of a planned conjunctive management model.

INDIA'S READINESS FOR SUSTAINED CONJUNCTIVE MANAGEMENT

Irrigation planners and managers in Asia need to recognize that the era of construction of irrigation projects in Asia is rapidly coming to a close; the challenge now is to improve the management of public irrigation assets, ignoring the role of private groundwater irrigation in canal command means missing out on a great opportunity for unlocking value from irrigation systems; Asia's semi-arid regions its own model of managed aquifer recharge and sustainable agricultural water solutions. Indian agriculture is already plumbed for highly effective conjunctive management of surface and groundwater. All that the sector needs are reconditioned surface systems and a conjunctive management protocol.
Conjunctive management is at work, for example, when canal irrigation system managers purposely direct surface water deliveries away from water-logged areas to groundwater depleted areas; or when they suspend canal supplies during the rainy period to provide irrigation during dry season; or when they use treated urban wastewater to supplement fresh canal or groundwater supplies. In Gujarat state of western India, the Government has constructed a 600 km long spreading canal to use surplus flood waters from Kadana and Sardar Sarovar reservoirs in the south to recharge parched aquifers of North Gujarat to counter groundwater depletion and reduce power subsidies to irrigation. This is a good example of conjunctive management of surface and groundwater.
India's conjunctive management potential has increased enormously thanks to a booming groundwater irrigation economy in the command areas of surface irrigation systems. However this potential is far from being fully utilized. Canal irrigation managers often ignore or are unaware of the benefits of conjunctive management. Moreover, poor rule enforcement in canal commands also makes conjunctive management difficult. As a result, conjunctive management in many Indian systems happens but largely by default through private entrepreneurial action by farmers.
Purposeful conjunctive management of surface and groundwater requires a mind-set change among irrigation managers and tighter rule enforcement, besides, of course, modernization of canal and irrigation network. Institutions and management structures need to take up proactive and purposive conjunctive management of rainwater, surface water, wastewater, and groundwater.

EXAMPLES OF SUCCESSES AND FAILURES OF CONJUNCTIVE USE

It is acknowledged that conjunctive use of groundwater and surface water already occurs in most countries where irrigated agriculture is practiced, both in the developed as well as developing countries. However, it is also recognised that whilst conjunctive use is probably the norm more so than the exception, its operation within an integrated water management framework is where adoption is significantly lacking.

Foster have described the setting for conjunctive use in Uttar Pradesh State in India, which is categorised as a humid but drought-prone middle alluvial plain hydrogeological setting. The alluvial plains of the Ganges Valley (the Indo-Gang etic Plain) in Uttar Pradesh, India are underlain by an extensive aquifer system holding groundwater that represents as much as 70 per cent of overall irrigation water supply. This is one of the largest groundwater storage reserves in the world. Its utilisation as a water resource has primarily arisen in response to reduction in supply and unreliable operation of the irrigation canal systems. The aquifers are directly recharged from infiltrating monsoon rainfall but also indirectly from canal leakage and poor applied irrigation efficiency (i.e. excess rates of field application); a common scenario in such hydrogeological settings.

Increasing groundwater abstraction has resulted in a declining water table, particularly in high intensity 'groundwater exploitation zones', whereas in other areas (in some cases within 10-20 km), flood irrigation and canal leakage have maintained shallow water tables. The decline in water tables in some areas is correlated with evidence of irrigation tube well dewatering, yield reduction and pump failure, together with hand-pump failure in rural water-supply wells. Conversely, threats arising from shallow water tables elsewhere are evident in around 20 per cent of the land area being subject to shallow or rising groundwater levels, with and salinization leading to crop losses and even land abandonment soil waterlogging. (Foster et al., 2010).

In the light of the challenges posed by rising water tables in some areas, and declines in the water resources elsewhere, in the Jaunpur Branch canal-command area in Central Pradesh a 'more planned conjunctive-use approach' is being implemented.

These activities are being aligned with the pursuit of an appropriate management plan, for which the land surface has been subdivided on the basis of hydrogeological and agro economic criteria into 'micro-planning and management zones'. For each *zone* a canal reach (e.g. head, mid or tail) is assigned with an indication of current irrigation canal flow and water table level. The irrigation water service situation, groundwater resource status and groundwater management needs are then identified.

IWMI (2002) describe the situation for the western Indo-Gang etic plain, where, although rainfall ranges between 650 and 1,000 mm annually, only 200 mm naturally percolates through soil layers to recharge underlying aquifers. In this area, like many others in India, groundwater pumping by farmers exceeds recharge (from rainfall and leakage from surface waters (canals and rivers) and application excess). Farmers are at the mercy of monsoon rains, which can fail to provide water when and where it is needed. The high concentration of rainfall, over a 3 month period, means the majority of water runs off the already saturated soil. During the dry season, a lack of canal water means a reliance on pumping from groundwater stores, which are not totally replenished from the previous year, hence further depletion (mining) of the aquifer system

A ten year pilot project (the Madhya Ganga Canal Project) undertaken in this area has demonstrated a low cost way of utilising the excess surface water during monsoon season by conserving and rejuvenating falling groundwater reserves. The project involved diversion of 234 m3/s of monsoon waters in the River Ganga to the Madhya Ganga Canal, which feeds both the Upper Ganga Canal system and the Lakhaoti Branch Canal system. Through systems of unlined (unsealed) earthen canals, water is delivered to farmers for irrigation of water intensive monsoon crop such as paddy rice and sugarcane. The unlined nature of the canal systems and Infiltration of excess irrigated water facilitates the recharge of underlying aquifers, in which the water table was raised from an average 12 m bgl (below ground level) to an average 6.5 m bgl. Simulations showed that without such a Conjunctive management approach, levels would have continued to decline to an average depth of 18.5 m bgl over the course of the study.

The conjunctive management of surface water and groundwater has proved productive in terms of the average net income increasing by 26 per cent through reductions in pumping costs and improved cropping systems. It has demonstrated a more sustainable system through improved cropping patterns and more reliable and sometimes new (e.g. providing water in previously existing dry pockets) sources of water for irrigation and other uses, such as domestic/industrial supplies. During the dry season, drawdown from groundwater pumping prevents waterlogging and maximises storage space for recharge during the following year's monsoon.

Unused (often lined) drainage canals constructed in the 1950s to control water logging and floods are also being targeted as a means for diverting monsoon waters across India either for irrigation, storage and later use, or recharge to underlying aquifers. Modification of previously lined canals can aid their transformation into temporary reservoirs, where 'check structures' at suitable intervals slow down water flow and increase the aquifer recharge capacity of the carrier (Khepar *et al*, 2000 in IWMI, 2002).

The Mahi Right Bank Canal System in central Gujarat is one example of conjunctive use by default. Commissioned in the 1970s, the canal irrigation system provided water to 250,000 hectares of land that became waterlogged and faced secondary salinization. Over the years, about 100,000 private tube wells were constructed and became the major source of irrigation water in command areas. These tube wells now serve as vertical drains - excellent substitutes for capital-intensive lateral drainage system. Waterlogged areas shrunk and agriculture boomed in previously unproductive regions. Irrigation efficiency, once defined as cubic meters/hectare of canal supplies was low; but when now measured as cubic meters/canal and groundwater irrigated area together, it is very high.

The vast plains of Punjab offer the same story. Massive waterlogging and secondary salinization in the 1950s and 60s have eased or been eliminated by private tube well development.

Down south in Tamilnadu, many canal irrigation systems have been over-extended so much so that canal water supplies needed to be rotated to different blocks of command areas. In some systems, all canal water is supplied to half a command area for a certain number of months; the other half uses well water while waiting for its turn to canal water privileges. In other systems, the entire canal network is run for a particular season, with canal water deliveries confined to left side in one year and on the right side the next year.

The proliferation of tube wells in command areas has made it possible for irrigation system managers to distribute available surface supplies over a much larger area than was earlier possible. Moreover, farmers value groundwater recharge from canal irrigation as much as - sometimes even more than - direct irrigation benefit.

SOCIAL AND ENVIRONMENTAL BENEFITS THROUGH CONJUNCTIVE USE SCHEMES

In Utter Pradesh, a planned approach was implemented at the regional scale aimed at effecting changes to the water supply/demand balance by considering the nature of the complete water cycle for the area and how this behaved spatially and temporally. A series of actions were then undertaken to optimise the existing infrastructure so as to enable a larger amount of water to be accessed in a more efficient manner. It seems there was little in the way of State-sponsored investment and no apparent changes to management and/or regulation levels. However, local ownership was focussed on increasing the total water availability. The benefits of these actions have been widely reported.

As Bredehoeft said "Effective conjunctive management can probably only be accomplished by an approach that integrates the groundwater and surface water into a single institutional framework; they must be managed together to be efficient. Current institutions based upon the present application of the rules of prior appropriation make conjunctive management not practical." This is because the existing surface water rights are strongly maintained and enforced by the relevant water authorities and consequently groundwater is not able to be used in an unencumbered conjunctive use sense.

The social, technical and economic factors require consideration within the local context, as they are critical to developing the optimum management arrangements. However, the optimum approach may prove to be purely theoretical if implementation is inhibited by existing institutional or policy structures. This specifically applies to the legal "ownership" of water rights, the ability of local bodies or water user associations to make day to day decisions and the ability to undertake effective Groundwater resource accounting critical for effective Management in a 'changing world'.

GOVERNANCE APPROACHES

Uttar Pradesh conjunctive use example, make the point that "multi-faceted governance arrangements are necessary for successful management of smallholder surface water irrigation systems. In managing conjunctive use, these arrangements become more complex. The greater complexity in management arises from the need for coordinated management of the two resources through greater participation and networking of stakeholders at each stage of water allocation, use and management." Further, Livingston subdivides water governance models for water supply systems into three types: Bureaucracy, Community and Market. Governance approaches may favour one part of these three, but will ultimately include elements of all.

The governance model will need to address four areas of endeavour: Legislative, Organisational, Capacity and Socio-political. In many countries, the organisational aspect will require the most significant changes to be made.

INSTITUTIONAL STRENGTHENING

Institutions that manage water, at both the national and regional scale will need to be strengthened to remove impediments. This will require the adoption of frameworks that promote integrated water resource management where surface water and groundwater functions operate collectively towards a single over-arching objective, and the function of water and agriculture ministries are also aligned for this purpose. Institutions will need to be clear on who operates and manages irrigation commands; arrangements that may be inclusive of either the public or private sphere, or a combination of both.

POLICY AND LEGISLATION

In many instances, there will be a need to understand and review the current approaches to allocating rights to water, and the form and attributes of those rights. In many situations, policies and regulations may be poorly formulated and hence not operating efficiently to achieve the intended outcomes. Effective water allocation planning is paramount. Such planning will need to be supported by strong national policy and to occur within a framework that ensures sustainable levels of take and use of the resource. This will require significant technical input, especially within the context of the need to assess the available consumptive pool.

PLANNING

By its very nature planned conjunctive use will require a strong management platform. There is a need to clearly define objectives, outcomes, activities and performance measurement and compliance arrangements. Such plans should be based around water allocation mechanisms and have regard to the technical understanding of the total consumptive water available.

Plan implementation will require definition of investment requirements and decisions about who will make those investments, and who ultimately pays. Ideally, planning should incorporate the triple bottom line notions of achieving environmental, economic and social objectives.

MARKET AND PRICING APPROACHES

Surface water and groundwater will always have differential cost structures that apply to users. In centralised government systems, these cost structures may be heavily subsidised as a result of related policy decisions (for instance, those for food and energy) and there may be unwanted outcomes as a result; usually these relate to poor water use efficiency outcomes. In general, groundwater users fully finance their associated infrastructure whereas surface water infrastructure has been either wholly or partly subsidised by the State. The different ownership models contribute to differential cost impacts for irrigators, leading to decisions that are inconsistent with optimised planning objectives. Conjunctive management will need to understand and remove these impediments. State-sponsored ground-water development is an area where investment may be required. There will also be differences in economic approaches at the macro and micro scale, and any activity to enhance the water market needs to acknowledge the two different scales of benefits. This is also true where economic incentives are implemented.

ON THE GROUND IMPLEMENTATION

Planned conjunctive use management will benefit strongly from, and possibly require, strong ownership by the irrigated farming sector. This can be achieved by building strong local water user groups through targeted education and enabling actions. In the past, communities have been focused upon single issues (either surface water or groundwater) and there has been a reluctance to engage in management issues associated with the other side of the resource picture that would require reorganisation to better reflect the distribution of users. Overcoming this issue is exacerbated by a number of factors including the absence of a revenue base for cost recovery and the politicisation of the user groups towards maintaining subsidised surface water supplies.

USE OF FINANCIAL AND MARKET BASED INSTRUMENTS TO PROMOTE PLANNED CONJUNCTIVE USE

Financial and market based instruments (FMBI) are a range of financial and economic measures which can be used to encourage specific actions and trends. In the context of water resource planning, FMBI can be direct financial incentives (e.g. taxation reduction, subsidies to lower electricity prices) or disincentives (e.g. taxation increases) or alternatively indirect trade-offs or offsets (e.g. pollution reduction schemes) and the introduction of water trading.

The introduction of clearly defined water "rights", the application of well-defined caps (i.e. maximum limits of use of groundwater and surface water) and then the introduction of a water trading regime can operate to strongly facilitate more efficient total water use. Surface water trading regimes currently operate in many countries; however, groundwater trading regimes are not so common. Surface water to groundwater (and vice versa) trading regimes are rare. Nonetheless, water trading can represent a strong market instrument to encourage conjunctive use, if it is managed appropriately. There are however few examples in the world where this has occurred. This is especially an issue where the market mechanisms are not designed to account for environmental impacts (e.g. salinity effects).

A SUGGESTED SET OF CONJUNCTIVE USE PRINCIPLES FOR CONSIDERATION WITHIN A GOVERNANCE APPROACH

The following is a suggested set of principles for the implementation of conjunctive use management within existing irrigation commands where existing infra-structure and historical governance arrangements are in place.

1- Planning should be undertaken with full and detailed knowledge of the characteristics of both the surface water and groundwater systems, existing system operations and the demands of the cropping systems;

2- Goals should be established that are intended to optimise the water supply/demand balance, Irrespective of existing institutional, governance and regulatory models;

3- Revised institutional arrangements underpinning the new conjunctive management model must be supported with a strong policy and legislative base;

4- The combined surface water/groundwater system and their use should be managed so as to optimise net economic, social and environmental benefits taking into account national energy, food security, population and poverty reduction, sustainability and climate change policies and programs;

5- Stakeholder participation should be encouraged.

From an operational point of view, some key guidelines to implementing conjunctive management include:

1- A technically robust understanding of stream-catchment-aquifer interactions;

2- A water balance that is inclusive of connectivity between the surface and groundwater systems;

3- Technical assessment techniques commensurate with the understanding of the hydrological system and with explicit recognition as to the limitations to the validity and applicability of information;

4- A strategic monitoring program for the catchment including the alignment of groundwater and Surface water monitoring. Monitoring regimes should recognise the differences between assessments monitoring and management monitoring. Management monitoring refers to the monitoring of Management rules and processes whilst assessment monitoring refers to monitoring of the technical or scientific aspects of stream-aquifer interactions

CONCLUSIONS

1. There are a range of settings within which conjunctive use management can occur and there do not appear to be any situations where conjunctive use management should not be practiced;
2. Planned conjunctive use management is far better than spontaneous conjunctive use;
3. Most development has already occurred and no new "Greenfield" irrigation developments are likely at a significant scale. Most implementation of conjunctive use management will be by retro-fitting management arrangements to already existing systems;
4. Poverty reduction in irrigation areas is closely linked to water supply efficiency and hence to conjunctive use management;
5. The regulatory settings for water management for different sovereign States will be the most important setting for management approaches. Any institutional strengthening will need to be supported by strong policy and possible legislative changes;
6. Conjunctive use management will be linked to sovereign policies related to energy, climate change adaption and to food security and hence a broader governmental approach will need to occur;
7. An important part of planned conjunctive use is the identification of the true total cost of water resources and the separate cost to individual users (for example, electricity subsidies are very common). The total real cost and individual water user cost can be very different.
8. The degree of connectivity of surface water and groundwater is an important technical consideration, but not one that will greatly influence whether conjunctive use management is successful;
9. Institutional strengthening around groundwater management and a fully integrated water agency will be a major challenge in most areas;
10. Public education and supporting technical assessments will be an important part of conjunctive use management.

REFERENCES

1. Bhatia, Ramesh (2005). 'Water and Growth', Background Paper for 'Water Economy of India', World Bank, Washington.
2. Bhattarai, Madhusudan, Randolph Barker and A. Narayanamoorthy (2004a). Implication of Irrigation Multipliers for Cost recovery and Irrigation Finanacing, IWMI-TATA water Policy Programme.
3. Bredehoeft J D, 2011. Hydrologic Trade-Offs in Conjunctive Use Management. Groundwater Vol 49, No 4, pp 468-475.
4. Foster S and Garduño H, 2006. Integrated approaches to groundwater resource conservation in the Mendozan Aquifers of Argentina. GW-MATE Case Profile Collection, Number 6, World Bank, Washington DC. www.woldbank.org/gwmate
5. Foster S and Steenbergen F van, 2011. Conjunctive groundwater use: a 'lost opportunity' for water management in the developing world? Hydrogeology Journal DOI 10.1007/s10040-011-0734-1.
6. IWMI, 2005. Reducing poverty through integrated management of groundwater and surface water. Water Policy Briefing. Issue 13. International Water Management Institute, February 2005.
7. Joshi L. K., (1997). 'Irrigation and its Management in India: Need for a paradigm Shift', mimeo, National Workshop on Participatory Irrigations.
8. Murray-Rust H and Vander Velde E, 1994. Conjunctive use of canal and groundwater in Punjab, Pakistan: management and policy options. Irrigation and Drainage Systems 8:201-231, 1994.
9. Qureshi AS, Turral H, and Masih I, 2004. Strategies for the management of conjunctive use of surface water and groundwater resources in semi-arid areas: A case study from Pakistan. Research Report 86. International Water Management Institute
10. Sahuquillo A, 2004. Conjunctive Use of Surface Water and Groundwater. Encyclopaedia of Life Support Systems (http://www.eolss.net/Sample-Chapters/C07/E2-09-07-04.pdf)
11. Tsur, Y, 1990. The stabilisation role of groundwater when surface water supplies are uncertain: the implications for groundwater development. Water resources Research, Vol 26, No 5
12. World Bank, 2006. Conjunctive Use of Groundwater and Surface Water. Agricultural and Rural Development Notes, Issue 6

REQUEST FOR FEEDBACK

Dear Readers

At the very outset, International Journal of Research in Computer Application & Management (IJRCM) acknowledges & appreciates your efforts in showing interest in our present issue under your kind perusal.

I would like to request you to supply your critical comments and suggestions about the material published in this issue, as well as on the journal as a whole, on our e-mail **infoijrcm@gmail.com** for further improvements in the interest of research.

If you have any queries, please feel free to contact us on our e-mail **infoijrcm@gmail.com**.

I am sure that your feedback and deliberations would make future issues better – a result of our joint effort.

Looking forward to an appropriate consideration.

With sincere regards

Thanking you profoundly

Academically yours

Sd/-
Co-ordinator

DISCLAIMER

The information and opinions presented in the Journal reflect the views of the authors and not of the Journal or its Editorial Board or the Publishers/Editors. Publication does not constitute endorsement by the journal. Neither the Journal nor its publishers/Editors/Editorial Board nor anyone else involved in creating, producing or delivering the journal or the materials contained therein, assumes any liability or responsibility for the accuracy, completeness, or usefulness of any information provided in the journal, nor shall they be liable for any direct, indirect, incidental, special, consequential or punitive damages arising out of the use of information/material contained in the journal. The journal, neither its publishers/Editors/ Editorial Board, nor any other party involved in the preparation of material contained in the journal represents or warrants that the information contained herein is in every respect accurate or complete, and they are not responsible for any errors or omissions or for the results obtained from the use of such material. Readers are encouraged to confirm the information contained herein with other sources. The responsibility of the contents and the opinions expressed in this journal are exclusively of the author (s) concerned.

ABOUT THE JOURNAL

In this age of Commerce, Economics, Computer, I.T. & Management and cut throat competition, a group of intellectuals felt the need to have some platform, where young and budding managers and academicians could express their views and discuss the problems among their peers. This journal was conceived with this noble intention in view. This journal has been introduced to give an opportunity for expressing refined and innovative ideas in this field. It is our humble endeavour to provide a springboard to the upcoming specialists and give a chance to know about the latest in the sphere of research and knowledge. We have taken a small step and we hope that with the active co-operation of like-minded scholars, we shall be able to serve the society with our humble efforts.

Our Other Journals