



The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search

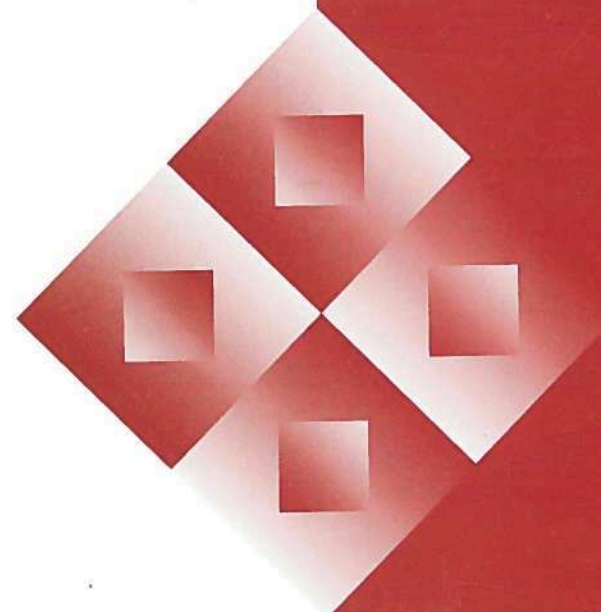
<http://ageconsearch.umn.edu>

aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

Stop per



AGREKON

Vol 40 Number/Nommer 1
March/Maart 2001



Published by the
Agricultural Economics
Association of South Africa

Gepubliseer deur die
Landbou-ekonomievereniging
van Suid-Afrika

MPUMALANGA DEPARTMENT OF AGRICULTURE. (1999). Conservation and environment. *COMBUD Budget of 1998/99*.

ROSENZWEIG, M.R & WOLPIN, K. (1993). Credit market constraints, consumption smoothing, and the accumulation of durable production assets in low-income countries: Investments in bullocks in India. *Journal of Political Economy*, 101(2):223-244.

STATISTICS SOUTH AFRICA, (2000). *1999 October Household Surveys*, Pretoria

VAN ZYL, J., KIRSTEN, J.F. & SARTORIUS VON BACH, H.J. (1994). *Poverty, household food security and agricultural production: Evidence from South Africa's communal areas in a period of drought*. Pretoria: Department of Agricultural Economics, University of Pretoria.

TOWARDS INSTITUTIONAL ARRANGEMENTS TO ENSURE OPTIMAL ALLOCATION AND SECURITY OF SOUTH AFRICA'S WATER RESOURCES

E.F.Y. Gakpo¹, L.A. du Plessis¹ and M.F. Viljoen¹

The ever-increasing pressure on the nation's water resources challenges water management institutions to be constantly changing in order to serve the changing needs. The institutional development of the water industry had been characterised by restrictions and inequitable distribution hence inefficient use of water from a total welfare perspective. The current institutional arrangement since the new democratic dispensation makes ample provisions to correct the deficiencies of the past. Despite the progress, water allocation is still supply-side dominated, the Minister holds the power, decision support and management tools are lacking or inadequate to help the proposed CMAs and WUAs to allocate water optimally and efficiently. In an effort to close this gap, an alternative institutional framework, Capacity Sharing (CS), to augment the current institutional arrangement is therefore proposed to address such issues. A strategy to drive water allocation through efficient pricing hence achieving water security under CS is suggested.

1. INTRODUCTION

Fresh water is one of the most essential natural resources for the survival of human and other living species. Variability in quantity and quality makes the usable forms of water to be scarce and hence a valuable commodity. Despite the limitations in the amount of usable water on the planet, there has been a nine-fold increase in per capita consumption of water worldwide since 1900, arising from changing technologies, and changing personal habits (Commission on Sustainable Development, 1997; Postel and Sandra 1992;). The continuous growth in the world population further increases demand at least in societies that do not adjust their water consumption patterns to current realities (Dellapenna, 1997). Global climatic change is equally likely to add considerable stress onto existing legal regimes as water management systems struggle to adapt to the altered precipitation and flow patterns. Many existing legal regimes according to Brans *et al* (1997), already feel stress as they struggle to respond to the increasing and changing demands for water without unduly destabilising the existing expectations expressed in the investment in water use facilities. The South African scene is not different. Geographically the country is an arid region and on the verge of water stress.

¹ Department of Agricultural Economics, University of the Orange Free State, P.O. Box 339, Bloemfontein 9300.

According to Backeberg, (1997) the S.A. water economy has already reached its matured stage. There is thus an increasing pressure on the country's scarce fresh water resources like in most parts of the world. The growing pressure coupled with the challenges resulting from the dawning of the New South Africa pose further demands on the reallocation and sustainable use of the nation's water resources leading to dramatic changes in the ways that the country wants its water resources managed. These changes are being driven by the desire to improve efficiency, equity, sustainable use and ecological health of river catchments.

In this paper an overview of the development of institutional framework for the South African water economy will be presented first. Secondly, the focus will be on the current institutional changes for the agricultural sector. Thirdly an alternative institutional arrangement Capacity Sharing (CS) leading to the formulation of a possible new water management and allocation strategy will be discussed. Thereafter an optimal water allocation and irrigation strategy for South Africa will be suggested.

2. THE INSTITUTIONAL DEVELOPMENT OF SOUTH AFRICAN WATER ECONOMY

2.1 Previous water institutional framework of South Africa

Historically, water law in South Africa evolved according to the changes set in motion by the social, economic and political developments. (Rowlston, B. et al, 2000). The creation of the Union of South Africa, in 1910 paved way for the first nationally applicable water legislation. The riparian principle was the central feature of water law and state involvement in water resource management was limited to irrigation related works. The post World War II industrial development in South Africa required water legislation to be adjusted, this gave birth to the 1956 Water Act. The act consolidated control, conservation and use of water for domestic, agriculture, urban and industrial purposes. This Act perpetuated the riparian principle in terms of "normal" flow and "private" water, which granted exclusive use but not ownership (Government Gazette, 1956). In the early 1990's, the New South Africa dawned, socio-economic and legal systems underwent fundamental restructuring. These changes are being driven by the desire to improve efficiency, equity, sustainable use and ecological health of river catchments. The seriousness of the Government to target these critical water management areas led to the promulgation of the Water Services Act (WSA) No. 108 of 1997 (Government Gazette, 1997) and the National Water Act (NWA) No. 36 of 1998 (Government Gazette, 1998). Jointly the two new laws provide an

integrated legislative framework within which South Africa's water resources must be managed.

2.2 The current water institutional framework of South Africa

A host of factors led to the formulation of the new Water Act. Among them include fulfilment of a "better life for all" promise, addressing the injustices of the past, the continuous growth in pressure on the water resources as a result of ever increasing water users, ecosystem issues, sustainability and also international concerns pertaining to water resource sharing. It is thus important to emphasise that the reform of South Africa water law has been driven not just by the demands of equity and social transformation. Even without the political change, the basic reality would still have to be addressed as the same amount of water has to be shared between larger users and the growing needs of our developing society (Muller, 1999). To review the Water law a set of basic principles was developed through an all-inclusive consultative process (Department of Water Affairs and Forestry, 1997). In summary the following can be mentioned:

- Constitutionally the responsibility for managing South Africa's water resources will rest with the national government.
- The riparian rights system to be abolished and replaced by time-limited authorisations.
- "Reserve" which comprises water to satisfy people's basic human needs and water to sustain ecological functioning, enjoys first priority in allocation.
- A well-formulated pricing strategy based on price differentiation will be institutionalised.
- Catchment based institutions will be formed to decentralise water resource management to a more local level. International obligations to river basin sharing to receive more attention.

Finally, public consultations must be a prerequisite to the implementation of any of the major provisions.

The provisions made in this Act specify principles and instruments, which may lead to efficient management and use of water resources. However, the framework also appears to have some vague provisions especially regarding

water markets. This may lead to uncertainty in decision making by water users especially in the irrigation sector. Thus the Act can be an obstacle to the achievement of sustainable development and water security, at the same time the exciting and challenging opportunities offered need to be complemented.

For a smooth implementation of the new Act there is an urgent need for the establishment of new and appropriate institutions. All the institutions that were in existence must be replaced or transformed in order to become functional in the new order. Below are the main institutions that will give execution to the New Act.

- *Catchment Management Agencies (CMAs)*

The act provides for the progressive establishment of CMAs. The purpose of establishing these agencies is to delegate water resource management to regional or catchment level and to involve local communities.

- *Water User Associations (WUAs)*

These are also water management institutions but their primary role differs from the CMAs. They operate at a restricted localised level. Former institutions like irrigation boards, water control boards, are to be restructured as WUAs.

- Another new institution to be established under the NWA is the *Water Tribunal*. Basically this will handle appeals and all aspects of dispute resolution in support of the activities of CMAs, WUAs and any other water management institution. The Judiciary will also play a vital role of guaranteeing that the rule of law prevails in the entire water industry.

In the past just like the present, water allocation is more supply-side dominated. This may hamper decision making of the water user as his interests and needs are not completely catered for. The establishment of CMAs and WUAs is applauded but the decision support and management tools they need to function effectively may be inadequate if not lacking. This has been identified by the Directorate of Catchment Management of The Department of Water Affairs and Forestry, who is currently embarking on a huge capacity building and education strategy to enable these water management institutions to function effectively (Department of Water Affairs and Forestry, 2000). However, it will take quite some time before the WUAs are in position to allocate water efficiently. A user friendly institutional arrangement like Capacity Sharing (integrating supply and demand side

management) can be adapted and used with the current provisions of the NWA with minor adjustments to achieve the national goal of efficient water use more speedily.

3. POTENTIAL OF CAPACITY SHARING

Dudley and Bryant (1995) defined CS as an institutional arrangement and property rights structure for allocating water among multiple users of water resource systems which include storage reservoirs. It provides each user, or group of users, of reservoir water with perpetual or long term rights to a percentage of the reservoir inflows and percentage of total reservoir capacity or space in which to store those inflows and from which to control releases.

The CS concept is presented in Figure 1. Essentially, the total capacity comprises a single or multiple reservoirs, a defined section of a river or group of rivers linked together. Capacity shares are bulk or retail. Bulk shareholders will be nations, provinces, industry and the like with limited incentives for efficient use of water and related resources. Households, firms, farms or any end user can own retail shares. The retail share holders have great incentives for efficient use of water and also enjoy the privilege of making own supply and demand management decisions.

Apparently CS is feasible under multiple purposes. From urban use where the relevant water authority would obtain capacity shares by market or non-market means and makes releases to users over time as desired, to in-stream or river valley environmental use, flood control, hydropower generation, recreation on lake surface. A preliminary analysis of the feasibility of CS (Dudley, 1988) stipulated that, capacity sharing coupled with market transferability of shares by auction will give all water users a greater security of tenure in water use compared with other water allocation alternatives. For example, as urban and environmental management demand grows over time, irrigation users need not fear that their individual reliability of supply will change without them deciding to sell their shares at market value. Similarly, urban and environmental users are aware that their shares can always be expanded as demand grows by paying the market value for extra shares. Most advantages in using CS can be derived from its features.

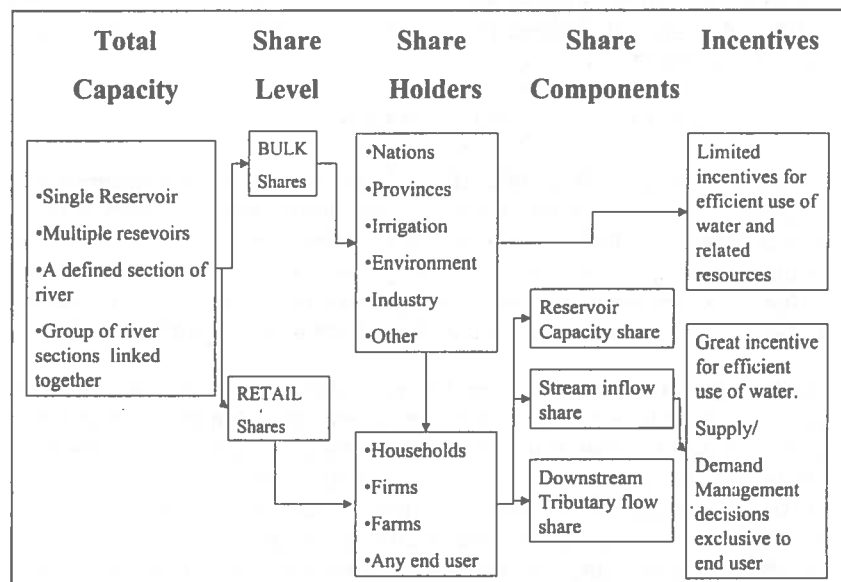


Figure 1: The concept of capacity sharing

3.1 Features of capacity sharing

3.1.1 Property Rights

CS provides water property rights, which are explicit, exclusive to share holder and enforceable by law. Such property rights form an excellent basis for water markets for water already in the reservoir or streams, or for long-term rights to future water. (Dudley & Bryant, 1995).

Certain features of CS are criteria on which all water allocation institutions might be assessed. These features as documented by Scott (1994) include:

- Security of tenure so that users have sufficient confidence of continuous use to make optimal investment and maintenance decisions;
- Payment by users of the correct and full cost of the water they use;
- Predictability so the consequences of decisions do not cause unexpected surprises;

- Fairness so that users do not impose uncompensated advantages or disadvantages on others; and
- Reflections of public values so that water quality and in-stream needs are met.

Dudley (1990a) has identified other features typical of urban CS; a summarised version is presented below:

- Water in a CS reservoir would become a private property resource rather than a common property resource. Therefore users would have an incentive to conserve water when it is in short supply relative to requirements, and to use it freely when it is plentiful. They would take its opportunity cost into account.
- CS would provide equitable rationing in times of shortage.
- CS would have the consumption-reducing advantages of highly fluctuating water prices without producing a destabilizing effect on the consumers' finances.
- Supply authorities would stabilize net revenue as 'user pays' would apply to water collection and distribution facilities rather than water use as such. CS would also allow a high degree of separation between the allocation and revenue raising roles of water pricing.

One other attractive feature of CS is that, it can be implemented in isolated 'river sections' or reservoirs as and when required, with the degree of complexity determined by local requirements. River sections can be linked as and when conditions dictate. Management and measuring requirements can be refined as required over time (Doertenbach, 1998).

3.1.2 Markets

An integral part of CS would be the establishment of markets for water users to trade water use entitlement. Water markets will operate at two levels under CS:

- to transfer water already in storage, stream or channels; and
- to transfer long-term rights to parcels of shares in reservoir capacity and streamflows.

The water market ensures that water users cannot lose water rights to other users or government without market compensation they deem to be adequate. Thus the water market provides two very important ingredients to efficient and sustainable use of water and associated resources in the long term. These include *security* of tenure of supply rights of known reliabilities to users and the *flexibility* for water resources to move into alternate uses as conditions change (Dudley, 1994). The security of entitlement to water currently in their reservoir coupled with the estimates of the probability of inflow, puts users in position to decide on the quantity of water to buy or sell at any point in time. A water market spot price would also reflect current supply and demand conditions while possible futures markets would also allow users to further reduce risk (Dudley, 1990).

3.1.3 Security

By its unique nature of holding rights in perpetuity, CS offers a lot of security to participants. As envisaged by Dudley and Bryant (1995), the only way a CS share can be removed from a share holder would be via market transfers, unless the individual broke some laws that are put in place to protect natural or built assets. Should society decide that water resources were needed for an existing or new use, the specific body has to enter the relevant market be it reservoir capacity shares, reservoir inflow shares or downstream tributary shares and purchase them from whoever values them least. A unit of water in a reservoir unlike land, is indistinguishable thus under no circumstances will a situation arise where a particular shareholder's share will be at risk of being needed specifically (Dudley and Bryant, 1995). This provision under CS absolutely guarantees unbiasedness and protects the beneficiary's shares. Also in the event that part or all of a particular participant's share be required for a potential use, government would be obliged to assume the shareholding and pay compensation, for which market prices should serve as a good guide. CS therefore offers that peace of mind to the shareholders, knowing that they could not be deprived of their shares by any user or institutional interventions outside market operations.

3.1.4 Other Benefits

Besides the benefits that will accrue from defined property rights, security of tenure and water markets under CS, there is an added advantage of determining the value in use of different dimensions of irrigation water and possibly extending it to other water use sectors. Since capacity shares comprise of inflow shares and shares in storage space, the shareholder enjoys the leverage of managing effectively his supply and demand. Also the fact

that inflow shares take into account inflow probabilities which are derived from long periods of hydrological inflow data water supply reliabilities can be near perfection and hence the water user's decision to buy or sell water can hardly be impaired. Currently a three-year project sponsored by the Water Research Commission (WRC) is in progress where the institutional feasibility of CS as well as water allocation for the irrigation sector using CS is being investigated. A full methodology in this regard is already in place (see Viljoen, Dudley & Gakpo, 2000)

3.2 Shortcomings of CS

The immediate disadvantages of CS are threefold according to Dudley and Bryant (1995);

- The difficulty of sharing transmission losses resulting from evaporation and seepage since transmission losses vary according to the distance water must travel and the volume of water accompanying it in the stream.
- Both channel capacity limitations and reservoir maximum attainable release rates may mean that all share holders may not be able to release water from their reservoirs shares exactly at the same time and rate they prefer.
- Problems of obtaining accurate estimates of supply system losses, as regular reconciliation of loss estimates with actual losses are necessary.

In the South African situation, CS in the initial phase is likely to pose some administrative difficulties looking at the literacy level of farmers, who must now make their own management decisions.

3.3 CS in practice

Thus far the concept of CS is known to be operational only in two countries namely Zimbabwe and Australia. The first capacity sharing scheme in the Mazowe Catchment in Zimbabwe dated back as 1984, when eleven commercial farmers formed the first 'Combined Irrigation Scheme' (CIS) as described in the Zimbabwe Water Act of 1976. The entire CIS was legally considered as having a single Water Right. Therefore there was no reason in law why members of the CIS should not manage their individual sub-rights as described, as long as there was no prejudice to other right holders. As a result the CIS formulated a management system which allows members to manage their individual percentages of the water in the reservoir (Doertenbach, 1988).

The water in the reservoir was treated like money in the bank. Each of the participants was given a separate 'account', with a facility for both 'deposits' and 'withdrawals'. The new water to which the parent water right was entitled each month was quantified, separated into the appropriate percentages or fractions and 'deposited' into each individual account. There is absolute equity of access to the new water available each month and participants independently manage their own risk of supply. The new management system received broad approval from both the CIS members and non-member right holders. It was easy to calculate, easy to understand, mathematically verifiable and transparent. Natural river flow was quantified more accurately than ever before and was readily available to those with rights to river flow. The management also satisfied the original requirements of CIS participants, all of whom were free to manage their own stored water and risk of failure as their individual financial circumstances required, just as if they were owners of individual private reservoirs. CS has been successfully implemented in a total of eight private, medium sized and multi-participant reservoirs. It is considered to be time tested and a successful water allocation method in Zimbabwe currently (Doertenbach, 1998).

Capacity sharing was developed in response to water management problems associated with high uncertainty of demand and supply of irrigation water in the lower latitudes of Australia. This later extended to higher latitudes where supply and demand are deterministic. Its appropriateness to that environment for irrigation and other purposes, led to the incorporation of provision for its use in recent legislation passed by the Victorian government (Dudley and Musgrave, 1992). Strong evidence exists that CS provides a superior framework for water allocation compared to most alternatives. In Victoria (Australia) the concept has been enacted on the bulk capacity sharing level and had been a vital instrument in resolving conflicts between her and New South Wales over their sharing of the water resources (Scott, 1994). Also in the Namoi River Valley farmers have favourably accepted the concept of capacity sharing and eagerly await its implementation as they believe it will resolve their water management problems permanently. To investigate the potential for adoption and use of CS as an alternative water resource management technique world wide, it is necessary to point out the circumstances that are likely to steer water management thinking along this line.

In matured water economies such Australia, particularly northern New South Wales (Scott, 1994), South Africa and the Western United States demand outstrips supply, with sites for further development considered few and uneconomic. Compounding this situation is the fact that water resource systems have natural dynamic characteristics, with demand and supply

fluctuating seasonally. To avert a possible conflict between different water users from this kind of scenario, a sophisticated but user friendly system of allocating this resource, targeting the management of supply and demand becomes the priority.

Lang (1999) established the relationship between suitable water allocation systems and scarcity/competition for water. Results illustrated in Figure 2 showed that in countries or regions with increasing water scarcity, as the competition for water increases like in the case of South Africa, Australia and Western United States, the sophistication of the applied allocation system increases as well. In other words, in the areas with little competition for water it does not make sense to introduce a highly sophisticated allocation system (upper left corner). But in an area of high competition for water it is appropriate to design and introduce an advanced allocation system (top right corner) like CS.

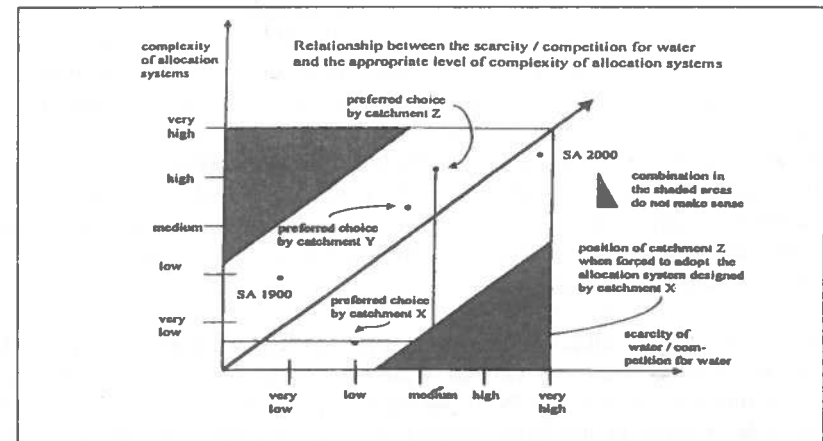


Figure 2: The design and selection of allocation systems

Source: Lang, 1999

Conflicts over water resource sharing between nations also stand a chance of being addressed amicably under CS. The institutional provisions empowers a single international body that will ensure the highest level holders of CS rights (i.e. individual countries) receive the agreed-upon shares of the resources by monitoring the runoffs, streamflows, ordered releases, actual releases, receipts and losses of the individual share-holder countries (Dudley, 1994).

With current institutional changes shifting more towards allocation, decentralisation as well as privatisation, economic viability and physical sustainability, and integrated approach to water management (Saleth and Dinar, 1999). Capacity sharing as a mode of water allocation is very appealing.

4. TOWARDS AN OPTIMAL WATER ALLOCATION AND IRRIGATION WATER SECURITY STRATEGY FOR SOUTH AFRICA

Stemming from the above discussions it is imperative to craft a development path that may lead to the water security of the irrigation sector with spin-offs for the broad national water resource base. The schematic representation of this path is depicted in Figure 3. In block 1 Figure 3, determining the economic value of water and getting the consumer prices right, starts the development path. This actually entails first conceding to the principle that water is a social as well as an economic commodity. It is therefore deemed necessary to treat this scarce socio-economic commodity with absolute care basing all judgements and management techniques on sound economic principles. Presently the full cost as well as the full value of water used in irrigation is unknown and this primarily account for the inefficient use of water. The problem may be determining the methods to use to actually arrive at these values. Determining the values and costs of water is therefore of paramount importance to any water resource management. Research already started to determine the demand function of water and hence the value of water in major river basins in the country.

Rogers *et al* (1998) documents the general principles of estimating the full cost and full value of water in various water use sectors. This approach was successfully used to estimate both the values in use for irrigated agriculture and costs of water in the Subernarekha and Haryana River Basins in India.

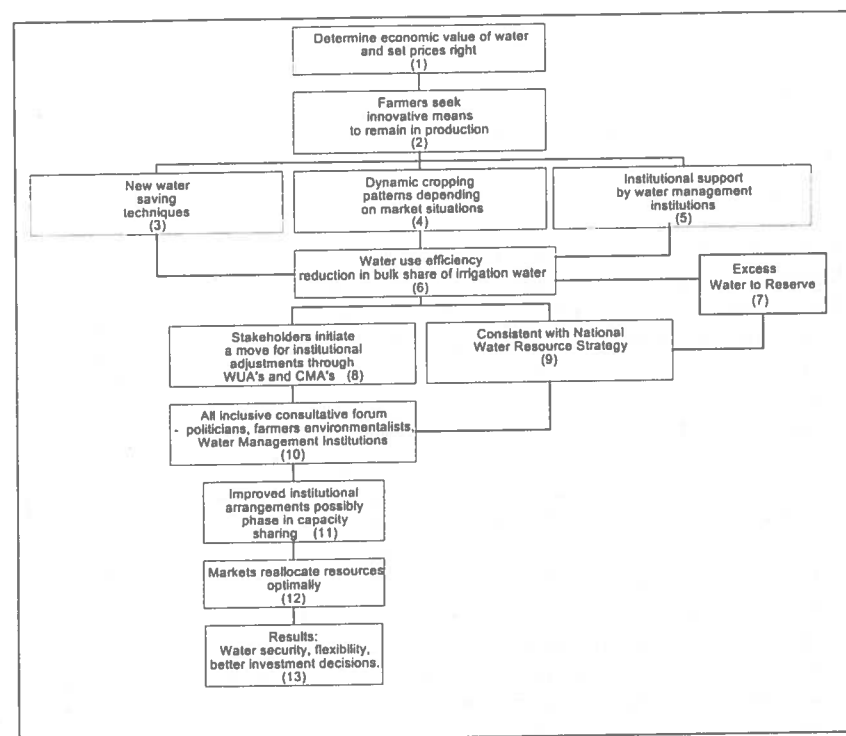


Figure 3: Developmental path for an optimal water allocation and security strategy

This method had partly been adapted and used to estimate the value of water for the Olifants River Basin (Louw, D.B and Van Schalkwyk, H.D 1997). This can be extended to other river basins to facilitate the calculation of reasonably acceptable prices of water to the irrigation sector in the various river basins countrywide.

The reaction of farmers to new price signals can not be fully predicted. Full cost recovery prices are likely to force inefficient and low value users out of irrigation (Bjornlund and McKay 2000). But on the average farmers may seek some innovative means of remaining in business, as referred to in block 2 (Figure 3). Production will become characterised by techniques like dynamic cropping patterns depending on market conditions, new water saving techniques will also be sought and pursued as reflected in blocks 4 and 3

(Figure 3) respectively. Farmers may rely more on Water Management institutions like the CMAs and WUAs for institutional support and information from research on appropriate methods of optimal water use (block 5). The outcome of this reaction is bound to enhance water use efficiency and reduce the bulk share of irrigation water as indicated by block 6 in Figure 3.

It is noted that irrigation farmers in South Africa along Sunday and Orange Rivers (Armitage & Nieuwoudt, 1998) are permitted to irrigate a large area if they adopt water saving techniques, this may negate the goals of this strategy. Food and Agricultural Organisation (FAO) predicts that irrigation in developing countries will expand at 0,8 per cent annually with Africa's expansion rate expected to be higher because of land availability (Lake & Souare, 1997). This may be used as a yardstick to control expansion and also serve as a wake up call for South Africa Water Resource Management, since expansion of irrigation needs to keep pace with development of water resources, if sustainable water use is to be achieved.

With South Africa on the brink of water stress with water resource development at a mature phase, it is suggested in this strategy that an institutional provision be made by CMAs in conjunction with WUAs to curtail unwarranted expansion of area cultivated and hence water use. Water saved in the process can thus be channeled to the reserve, a sector that is considered to be the national government's priority at the moment. Being the custodian of this resource government will welcome significant savings in water used by any sector. It will therefore be appealing to government to co-operate further with the irrigation sector should this goal of water saving be achieved. The Irrigation sector can exploit this situation by lobbying through the WUAs for the amendment of certain sections of the Water Act which they fear to be a limitation to water use efficiency at least in the irrigation sector (block 8, Figure 3). An example is the vague provision pertaining to water markets. An all inclusive consultative forum involving politicians, water management institutions, farmers and other stakeholders will have to be set up to revisit the current institutional arrangements as specified in block 10.

The final stages of the development path is likely to see the water industry decision-makers considering other institutional arrangements such as capacity sharing (CS) which thrives on well-defined water markets. Judging from the advantages of CS as enumerated above, the agricultural sector should be one of the main beneficiaries if CS is adopted. Market reallocation and consequently optimal use of water, which is typical of CS, will result.

5. CONCLUSION

The study of the present institutional arrangements for water management reveals that the current provisions will be sufficient to accommodate Capacity Sharing if minor adjustments are made to allow water trading. Concerning rights to water use it is suggested that long-term rights which is currently an issue in the NWA be replaced by long term-leases. These leases can be devised so as not to harm farmers long-term investments and resource management efforts. It is important for Government to hasten steps towards the introduction of full cost recovery pricing. This is likely to force inefficient and low value users out of irrigation and water markets will facilitate this process and provide compensation to the sellers.

The devolution of management of natural resources and its infrastructure to CMAs and WUAs is a positive step towards decentralisation. However, the introduction of market-based mechanisms and removal of all forms of government interventions are absolutely necessary if optimal allocation and efficient use of water is to be achieved in the near future. The steps taken by water managers thus far in conjunction with the above proposed policies will encourage a reallocation of water resources to higher value and more efficient users which is consistent with the concept of Capacity Sharing.

REFERENCES

- ARMITAGE, R. & NIEUWOUDT, W.L. (1998). *Discriminant analysis of water trade among irrigation farmers in the Lower Orange River of South Africa*. University of Natal, South Africa.
- BACKEBERG, G.R. (1997). Water institutions, markets and decentralised resource management: Prospects for innovative policy reforms in irrigated agriculture. *Agrekon*. 36(4):352.
- BJORNLUND, H. & MCKAY, J. (2000). *Are water markets achieving a more sustainable water use?* University of South Australia.
- BRANS, E. et al (1997). *The scarcity of water: emerging legal and policy responses*. London: Kluwer Law International.
- DELLAPENNA, J. (1997). Population and water in the Middle East: The challenges and opportunities for law. *International Journal of Environment and Pollution*, 7:72-111.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY (1997). *White Paper on water policy for South Africa*. Pretoria.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY (2000). *Development of a generic framework for catchment management strategy*. Directorate Catchment Management, Pretoria.

DOERTENBACH, B.D. (1988). *Practical experience with Capacity Sharing in the Mazowe Catchment, Zimbabwe*. (Unpublished Paper) Glendale Mashonaland Central, Zimbabwe.

DOERTENBACH, B.D. (1998). *Fractional water allocation in the Mazowe River catchment, Zimbabwe, and feasibility for national replication under the new Water Act*. (Unpublished Paper) Mazowe Valley Catchment Development, Zimbabwe.

DUDLEY, N.J. & MUSGRAVE, W.F. (1988). Capacity sharing of water reservoirs. *Water Resources Research*, 24(5):649-658

DUDLEY, N.J. (1990a). Urban capacity sharing an innovative property right for maturing water economies. *Natural Resource Journal*, 30:388-401.

DUDLEY, N.J., & MUSGRAVE, W.F. (1992). *Economics of irrigation water allocation under uncertain conditions*. Centre for Water Policy Research, University of New England.

DUDLEY, N.J. (1994). *An innovative arrangement with potential for improving the management of international water resources*. Centre for Water Policy Research, University of New England.

DUDLEY, N.J. & BRYANT, M.J. (1995). *The concept of capacity sharing and responses to questions posed on implications for irrigators*. Centre for Water Policy Research, University of New England.

GOVERNMENT GAZETTE. (1956). *Union of South Africa National Water Act No. 54*. 13th July 1956.

GOVERNMENT GAZETTE. (1997). *South Africa National Water Services Act no. 108*.

Government Gazette. (1998). *Republic of South Africa National Water Act no. 36*. 26th August.

LAKE, E.B. & SQUARE, M. (1997). *Water and development in Africa*. International Development Information Centre.

LANG, H. (1999). *The definition of water permits and the management of reservoirs in Zimbabwe, present state and options for the future*. (Unpublished paper) Harare, Zimbabwe.

LOUW, D.B. & VAN SCHALKWYK, H.D. (1997). The true value of irrigation water in the Olifants River basin. *Agrekon*, 36(4):551-560.

MULLER, M. (1999). *Transforming water law to achieve South Africa's development vision*. A case study in National Law. Department of Water Affairs and Forestry. Pretoria. South Africa.

POSTEL, & SANDRA. (1992). *Last oasis: facing water security*. New York:W.W. Norton and Co.

ROGERS, P., BHATIA, R. & HUBER, A. (1998). *Water as a social and economic good: How to put the principle into practice*. Global Water Partnership TAC, Windhoek, Namibia.

ROWLSTON, B., BARTA, B. & MOKONYANE, J. (2000). *Implementing New Water Law: A South African experience*.

SALETH, R.M. & DINAR, A. (1999). *Water challenge and institutional response*. Policy Research Working Paper No. 2045. World Bank, Washington, DC

SCOTT, B. (1994). *Capacity sharing explained*. Centre for Water Policy Research, University of New England, Armidale, NSW, Australia.

VILJOEN, M.F., DUDLEY N.J., & GAKPO, E.F.Y. (2000) *A methodological perspective on valuing water: A comparison between linear programming and stochastic dynamic programming*. AEASA Conference. 27-29 September. Sun City.