1 INTRODUCTION

1.1 Water for Irrigation

Good quality water is plentiful in Central Asia and ought not to be seen as a factor limiting agricultural production. In reality it is, both on account of the maldistribution and misuse of water abstracted from rivers and wells leading to salinisation and abandonment of land, but also due to increasing pressure for accountability in the context of restoration of the Aral Sea and the delta zones. It has long been evident that water productivity in Central Asia is one of the lowest in the world (WARMAP Review Stage Report, 1995) and the EC of IFAS has placed much emphasis on the need to make improvements. Some of the problems are evident in the colour photographs illustrating this report.

A WUFMAS simulation exercise demonstrated that increasing yield while maintaining water use is as an effective measure to raise water productivity as maintaining yield while reducing water consumption, but it would fail to address the other issues. On the other hand, in the current financial environment of the agriculture sector, without effective water charging and lack of incentives to operators, improved water management alone would be unsustainable. Therefore, it is argued that water productivity may be most favourably and sustainably improved by concurrently increasing crop yield while reducing water consumption. Sustainability would depend on the re-circulation of some of the extra “profit” to the operators.

Approximately as much water is wasted in the farm canal system as in the field during irrigation (WUFMAS Annual Report, 1997) but the resources available to the WUFMAS team in 1999 were insufficient to intervene in management of the canal system. WUFMAS proposed a field programme for summer 1999, in which improved water productivity would be demonstrated in selected fields by comparison with control fields. This report describes the success of this programme.

1.2 Water Productivity Defined

Water productivity may be defined in several ways. From Soviet tradition, the local perception of water productivity tends to be the physical quantity of crop product that can be produced by a unit volume of water, for example 4 centners of cotton per thousand cubic metres (tcm) of water, or 0.4kg per m^3. The first drawback of this approach is that comparisons cannot be made between crops. For example, 4 centners/tcm of cotton cannot be compared with 40centners/tcm of potatoes. The second drawback is that physical quantities do not equate the money value of the crop product with the cost of the water used.

Since 1996, WUFMAS has been monitoring true **Variable Costs** of producing crops in sample fields around Central Asia and the value of crop production from them. The difference, on a per hectare basis, is termed the **Gross Margin,** which may loosely be thought of as “profit per hectare”, taking account of all the expenses directly incurred in the production of that crop. In this report, as previously, it is measured in US$/ha, in order to make comparisons possible between Republics, and to stabilise costs monitored in local economies where real inflation is high. The adjusted gross margin may then be divided, either by the physical quantity of input used or by the variable cost of that input. In the case of water, the values are, respectively, the return to water in $/tcm or $/$ of water cost. With these indices, it is possible to compare the productivity of water for different crops in fields around Central Asia and anywhere in the world.

Financial prices are “market place” prices that reflect income and costs that the producer receives or must pay. In Central Asia, liberalisation of the markets is not complete. Even in Republics where price controls in theory have been removed, some price distortion remains due to the aftermath of state production, and supply cartels. Many commodity prices are not at the level they would be if goods were allowed to be exported and imported in a perfect market with robust competition, without any intervention by the state and cartels. Such calculated prices are **economic prices, t**hey are arguably more stable than financial prices, and are favoured by economists for planning purposes.

Economists argue that optimisation of resource use by Government requires that capital should be allowed to flow to enterprises that yield the greatest return. If casinos are more economically profitable than potatoes, then it follows that the market for casinos will be satisfied before capital flows to potato production. The price of potatoes would rise until equilibrium is reached between casinos and potato production and importation.

However, for water, this approach is unrealistic in the context of an existing, highly developed distribution system upon which millions of people in rural communities depend. Canals cannot be closed simply because capital flow has chosen casino development as a priority. It may seem therefore that crop gross margin return in $/$ invested in irrigating it, is an inappropriate water productivity index. However, the choice is rarely as stark as between casinos and potatoes and a much more pertinent question arises over the priority for expenditure in producing potatoes between inputs such as fertiliser, machinery, labour, pest control and water. Assuming an inexhaustible supply of capital, greatest crop gross margin is realised when the return to investment in any input is at its maximum level. It was not the objective of this study to establish production functions for crop inputs and this cannot be used to justify choice of the $ return/$ investment water index.

For the purpose of evaluation of the programme, the selected water productivity index therefore is economic gross margin return of the crop per unit of water used, for convenience, $/thousand cubic metres (tcm), calculated:

$$\frac{\text{(crop gross margin in \$/ha + cost of water at economic price in \$/ha)}}{\text{water applied during the vegetative period in tcm/ha}}$$

It is considered that water used in winter to aid land preparation and leach salts is not a variable cost, as it would be necessary for whatever crop is produced. This would not follow if the quantity of leaching water applied were a function of the crop and its tolerance of salinity, but this seems not to be the case at present. Pre-irrigation shortly before planting is regarded as a variable cost necessary for the germination of the crop. This applies where it is not clear if the pre-irrigation was for land preparation, leaching or recharge of the profile.

This water productivity index is complex, a function of crop yield and price, rate and price of all the inputs used, and the amount of water delivered to the field for the sole purpose of irrigating that crop. Its calculated value is affected by change in any one of these components, and the accuracy with which they are measured. WUFMAS has endeavoured to measure the physical inputs and outputs as accurately as possible. Prices used are not generally those precisely applicable to the sample field, since these, for a variety of reasons, are almost impossible to obtain. Every reasonable effort has been made to obtain and estimate appropriate local financial and economic commodity prices, but of these, it is crop price to which the index is most sensitive. The choice of the $ return/tcm of water index, rather than $ return/$ invested in water, also avoids the issue of the sensitivity of the index to the accuracy of the estimate of economic price of water. Nonetheless, all productivity indices discussed above have been calculated and may be found in the appendices to this report.

1.3 Targets for WUFMAS 1999

At the time of making the simulation exercise (December 1998), it was considered that a 75 percent increase in crop yield and a 40 percent decrease in in-field use of water would be feasible targets. If achieved, these together would achieve an estimated approximate 250 percent improvement in water productivity index (as defined above).

1.4 Field Programme in 1999

A selection of the original 36 WUFMAS sample farms was made, and on the basis of balancing the estimated cost of the programme with the funds made available, the number was limited to nine, one each per republic except for five in Uzbekistan. This was justified on account of the greater irrigated area and agro-ecological diversity there, and the much increased difficulties and cost of managing sites outside Uzbekistan. It was proposed that two similar fields should be selected by the supervisor on each farm, one to be designated as the demonstration and the other the control field. Eight pairs of fields were to produce cotton but the pair in Karakalpakistan would produce rice.

Final approval of the programme was received in mid-March, too late to properly address some of the issues raised. The main constraints to improved water management in the demonstration fields were seen as

- water supply to the field and the means to monitor and control it,
- land levels and length of furrows,

- compacted subsoil restricting root development.

By mid-March, it was too late to disburse the contingency funds to assist the supervisors to improve the water supply to the field and to organise levelling and ripping (sub-soiling) of the demonstration field before sowing of the crop.

Supervisors and national co-ordinators were called to a hastily arranged seminar in Tashkent before the end of March. The methodology to be employed to improve and monitor yield and water management was explained, and they returned to their farms with detailed notes, record sheets and in some cases with the first of the locally commissioned electrical conductivity meters for measurement of soil salinity. These notes are reproduced in Annex A. Using generalised data from the WUFMAS database on soil characteristics, infiltration rates, slopes and furrow lengths, each Supervisor was given a commentary on the fertility status of their fields. The water management program PUMA was run during the seminar to generate ideal irrigation regimes for the demonstration field. Supervisors were provided with commentary on the fertility status of the soil in their fields and guidance on fertiliser requirements and how to irrigate their fields.

Two teams of soil surveyors were formed and given training at Farm 24 in early April in topographic survey of the fields, making a brief description of the soil profile, taking soil samples, and measuring infiltration rate and penetrometer values. Their training and the equipment used are illustrated in the photograph section. They were despatched to visit all the selected farms, mostly by road, taking all their necessary equipment, but flew to Turkmenistan and used locally available equipment. The teams began reporting back to Tashkent with their samples and data from the end of April. Detailed analysis was made of field slopes and a program was prepared to calculate the Kostiakov-Lewis infiltration parameters from the infiltration data. From the new topographic survey data and the infiltration parameters, PUMA was again used to generate optimised water management criteria for the demonstration fields. This analysis was reported and field prescriptions were circulated in July. The report is attached here as Annex B.

During the season, the Regional Working Group Members made 36 and the consultant 16 separate visits to the farms as shown in the following table in order to give on-site training and assess progress:

Table Visits to Demonstration Farms in 1999

Farm no.	Republic	Oblast	RWG	Consul -tant
03	Kazakhstan	S Kazakhstan	8	3
09	Kyrgizstan	Osh	2	1
14	Tadjikistan	Leninabad	1	1
18	Turkmenistan	Mary	1	1
22	Uzbekistan	Surkhandariya	4	1
24	Uzbekistan	Syrdariya	8	5
28	Uzbekistan	Karakalpakia	3	1
34	Uzbekistan	Ferghana	5	2
35	Uzbekistan	Bukhara	4	1
Total			36	16

During a short visit by the consultant in September, further analysis of the data on the record sheets of the furrow irrigation tests was begun. Considerable disparity was apparent between the PUMA predictions and the data, and it emerged that a contributory factor was that values for the furrow shape parameters had been incorrectly assumed during earlier runs of PUMA. Analysis of furrow shape parameters was reported in September, and attached here as Annex C. A half-day seminar was organised in order to present the findings on water management to Supervisors, national co-ordinators and invited members of the Ministry of Agriculture and Water Resources of Uzbekistan.

In the period between August and September, all Supervisors organised field days on their farms that were well attended by staff of the farm, local hakimiyat and local offices of the Ministry of Agriculture and Water Resources. Some are illustrated in the photograph section of this report. In some cases, these events were reported in the local press and video films made at the event were shown on local TV.

During a short visit by the consultant in December to prepare this Annual Report, time only allows consideration of the essential issues related to the objectives of the programme. All data collected have been entered to the WUFMAS database and are available to *bona fide* users. The most import question is how closely have the field teams reached the declared target of increasing water productivity by 250 percent?