1. SUMMARY

Aim of the Report

The WUFMAS field team collected data during winter 1996/97 and the summer season of 1997 and the emphasis of this report is to summarise it, not to make detailed analyses of the data nor recommendations to the participating Governments. However, it is expected that the professional staff of Ministries and Institutes will make use of the database to augment their specialist studies when advising their Governments on agricultural development strategies (Activity 7, Form 1.5, Module 2b, Inception Report). However, some interpretation of the data and recommendations are given in Section 4 of this report.

Rationale of WUFMAS

A “norm” in western parlance is not even a recommendation but an average or modal value derived from a survey of how farmers use their resources given that each is free to make their own decisions on how to use them. The WARMAP project initially used official data, the “normative” values of the Soviet period, to estimate crop gross margins (the measure of economic worth of an enterprise) but the results were mostly negative and unrealistic. “Normative” values were instructions to farm operators to ensure the highest possible crop production but they are now largely irrelevant because farms lack the resources to implement them in full, they are inappropriate to a free-market economy and mostly they are unsustainable. The observation in 1995 that Central Asian farms were departing significantly from the “normative values” made an impartial survey of the actual use of resources particularly urgent.

Methodology and Farm Characteristics

The Water Use and Farm Management Survey (WUFMAS) in 1996 began a programme of systematic measurement of inputs and output in sample fields on 36 sample farms, located according to the distribution of irrigated land in the Aral Sea basin. Due to a budgetary limit, the sample farms were reduced to 22 in 1997. Data about the whole farm are collected annually and monthly from farm records. Enumerators measure and record the actual use of all inputs in each of 10 sample fields per farm, establish five sample plots in which agronomic measurements (including yield) are made, and the field’s production as recorded by farm staff. Data are entered on a set of record sheets using a codebook to identify materials, machines, operations and products. A survey of the soil in each sample field was made and periodic samples of soil, irrigation, drainage and ground water are sent to the SANIIRI research laboratory for analysis. Monthly average climate data are collected from the closest meteorological station but pan evaporation and rainfall are measured on farms by enumerators. Completed record sheets are returned monthly to a central office, for entry of data to the WUFMAS database in MS Access. This database is now very comprehensive and a valuable tool for planners at both farm and national levels, and to the developing commercial sector. This report is a summary and analysis of some of the available data.

Farms were kolkhozes when selected in 1995, and although some have since been substantially fragmented into small tenancies, with the emphasis by WUFMAS on recording activities in the sample fields the kolkhoz entity is retained. Total farm area averages 7,726ha, somewhat larger in Kazakhstan and Kyrgyzstan, and smaller in Tadjikistan and Turkmenistan. The proportion irrigated varies markedly from 93 percent in Turkmenistan to 26 percent in Kyrgyzstan, where much of the land is used for pasture and rainfed crops. Net irrigated area is about 80 percent of gross irrigated area on average, ranging from 65 to 94 percent in Kazakhstan and Kyrgyzstan respectively. Most sample fields are 5-10ha in area, with slopes in the range 0.05-0.5 percent and well to poorly drained.

The overall average cropping intensity was 108 percent, indicating a small amount of double cropping on some farms in Kazakhstan, Tadjikistan and Uzbekistan. Upland cotton and winter wheat dominate the cropping pattern, the former ranging from 31 percent in Kyrgyzstan to 49 percent in Uzbekistan, the latter from 4 percent in Kazakhstan to 38 percent in Turkmenistan. Rice and forage crops are important in Kazakhstan (29 and 30 percent respectively) but overall occupy only 11 and 13 percent respectively. Other classes of crops are unimportant in terms of land use, apart from plantations occupying 6 percent overall but 32 percent of the Tadjikistan farms. Employment on farms reduced between 1996 and 1997 in the liberalised economies but increased in Turkmenistan and Uzbekistan.

Climate and Evapotranspiration

Monthly mean data were collected from the met stations nearest to the pair of farms during the following month but in some cases they were replaced by data from Glavhidromet. January is generally the coldest month, but the winter of 1996/97 was markedly warmer than average with farms from Kazakhstan to the south of Uzbekistan experiencing minimum monthly temperature means in the range –7.6 to 7.4^{o}C. The highest temperature was in July, the highest monthly mean maximum on farms from Kyrgyzstan to Uzbekistan ranging from 26.7 to 32.4^{o}C, the 1997 summer being hotter than average. The winter was markedly more humid and the summer less humid than average, relative humidity ranging in winter from 64 to 82 percent on farms from Kazkhstan to south Uzbekistan in relation to temperature, and in July from 21 to 49 percent on the same farms. Winds were mostly light to moderate in the range from 52 to 458 km/day, the greatest variation being in Kazakhstan, with the period from January to May being the windiest. Variation in solar radiation is determined mainly by day length with minimal values in mid-winter as low as 5.8 MJ/m^2/day in Kyrgyzstan and the highest value of 30.2 MJ/m^2/day in central Uzbekistan in mid-summer. Most rain falls in March and April, but the winter of 1996/97 was drier and the early summer was more moist than average. In 1997, May rainfall varied widely from 90mm on farms in Kyrgyzstan to 12mm on one farm in Uzbekistan, but September was very dry with almost no rain recorded.

Reference crop evapotranspiration (ETo) was calculated from climate data in CROPWAT (FAO, 1997). On average in mid-winter ETo was about 1mm/day, rising to 7.4mm/day in July and, as such, in both seasons values were higher than average. Rainfall and pan evaporation (Eo) was recorded daily on each farm but estimates of ETo from it cast doubt on some pan coefficients used by field staff, an issue that requires more attention.

Soil Resources, Salinity, Fertility and Fertiliser Use

Profiles of the soils in the sample fields were described, some measurements made in the field, and samples were analysed in the SANIIRI Research Laboratory by a wide range of local and international methods.

Local criteria for soil texture are quite different to those used internationally, particularly with respect to local "physical clay" (particles <0.01mm) which includes most of the international silt fraction. This makes it impossible directly to relate local and international textural classes. According to USBR criteria, 74 percent of samples had 10 to 30 percent clay, 62 percent had more than 50 percent silt, and 69 percent had less than 30 percent sand. On classification, only 7 percent of samples were clay and silty clay and 1 percent sand, but 92 percent were variously loams, predominantly silt loam. By contrast, the Katchinsky system classified 73 percent of the samples as loams, 17 percent as clays and 10 percent as sands. About 56 percent of sample fields had uniform texture in the top 1m, but the proportion was much less in Kyzl Orda, Karakalpakia, Marie and Osh oblasts due to alluviation.

The issue of soil compaction and ploughpans deserves more attention, as their effect on yield is considerable, affecting root development and increasing the damage due to moisture stress. Thirty six percent of samples had bulk density greater than 1.5g/cm^3, the threshold for serious crop loss. It is estimated that crops overall lose some 25 percent of yield due to compaction but the extent to which the situation could be improved is not clear. Measurements using a penetrometer revealed that pans about 35cm deep caused by poor land preparation and other machinery operations were very common particularly in the central zone of the Aral Sea basin (>60 percent of fields). Overall, about 40 percent of fields are affected in this way, with very significant implications for the irrigation schedules.

The soil moisture that is available to the crop (AWC) is defined differently by local and international methodologies. It is an essential parameter for irrigation scheduling by the FAO methodology and is costly to measure so that a predictive model using characteristics available from existing soil survey data would be useful. The moisture content of sample soils was measured by international method on pressure membranes, and the AWC between field capacity and permanent wilting point (pF2.0-4.2) was found by difference. It varied from 15.2 to 16.0 percent (v/v) from loam, through silt loam to silty clay loam, the most common soil textural classes in the samples. Values in individual samples ranged from <10 to >21 percent AWC with 74 percent of samples being in the range from 13 to 19 percent AWC. Prediction of AWC on the basis of clay percentage alone, and by using a more complex model with salinity, pH, silt, clay and bulk density was unreliable and further work is recommended.

Soil salinity is a prominent issue in Central Asia and over half of irrigated soils are commonly held to be saline. Total soluble salt in the soil is the usual measure, but in certain areas the contents of chloride alone and “toxic salts” are used as indices. Chloride is not a significant ion in most areas so “toxic salts” is far superior to other indices as it discounts soluble calcium sulphate, the predominant salt in most areas that has no effect on crops. It is inconvenient and costly as a routine measure of soil salinity so the project has been studying its replacement by the more common international measure, the electrical conductivity of a soil suspension, $EC_{(1:5)}$. Measurable in the field using a portable conductivity meter, this method is rapid and convenient but the drawback is the need for a conversion factor to covert readings to the equivalent EC_e of a saturation extract on which salinity criteria are based. The internationally familiar factor of 6.4 is not appropriate on account of the EC of calcium sulphate being limited to 2.2dS/m. Factors ranging from <2 to >4 have been obtained in the laboratory, and the best fit between the “toxic salt” method and EC_e was obtained with an average factor of 3.5, but further work is recommended. On this basis, only 5 percent of samples were seriously saline, 9 percent moderately so and 29 percent only slightly saline. Taking into account that WUFMAS sample fields may not be located on the most saline areas, soil salinity seems not be as serious as is commonly believed. However, there is some evidence that the severity of salinity may be increasing due to failure of the drainage systems, inadequate leaching and use of poor quality water for irrigation. Comparison of results between only two years is circumstantial but the salinity of sample fields increased on average by 51 percent but in places by much more.

Using FAO criteria, the estimated effect of salinity on production generally is not serious since the worst scenario is an average loss of 8 percent of rice yield in Karakalpakia. In the majority of sample fields probably there is no measurable loss due to salinity per se, but in some fields as much as 50 percent of the yield potential may have been lost. Salinity effect in cotton is difficult to assess, as the plants become very salt tolerant as they mature but are sensitive when young. There was no discernible yield loss up to the maximum salinity encountered, an ECe of 12dS/m in mid-season, except in two saline fields in which the crop was abandoned on account of germination failure.

The organic matter content of soils is mostly low to very low (<0.5 percent) but slightly higher in the river delta zones, and although important to soil fertility, in local conditions it is unrealistic to increase it significantly. Despite continued use of heavy rates of N on cotton, particularly in Uzbekistan, most nitrogen retained in the soil is in organic form because levels of mineral N and $C:N_{mineral}$ ratios are low. Available phosphorus levels are relatively high considering the current generally low rates of application of fertiliser P and favourable conditions for P-fixation (abundance of Ca and high pH, generally between 7.5 and 8.3). One third of samples were “high” in available P, probably the legacy of heavy rates of application in the past, and only 13 percent were clearly deficient. There is circumstantial evidence that the soil P status is declining with substantially fewer fields in the “high” class in 1997 than in 1996. Detailed analysis for exchangeable potassium was made only on few samples and of these only 16 percent showed clear deficiency. However, cotton is a gross-feeder for K so that on this evidence yield response may be expected in at least 26 percent of fields.

Fertiliser use in general is only a small fraction of the former “norms”, but the shortfall is least with nitrogen fertilisers, in cotton, and in Uzbekistan. Several N fertilisers are available but as most of the regional production capacity is located in Uzbekistan it is not surprising that most is retained there. A substantial subsidy remains on locally produced fertilisers compared with their import parity prices, with urea, DAP and muriate of potash being about 30, 60 and 50 percent of their economic farmgate prices respectively. This may be the consequence of subsidised energy and low depreciation costs on plant and equipment, rather than a deliberate policy of subsidising fertiliser.

On average, 46 to 142kg N/ha was applied to cotton or 21 to 60 percent of the norm, from Kazakhstan to Uzbekistan respectively. The average yield of cotton in Kazakhstan exceeded that in Uzbekistan so that 142 kg N/ha probably is not yield limiting and rates in Uzbekistan could be reduced for present yield levels. Relatively more nitrogen is applied to winter wheat in Turkmenistan and Uzbekistan, raising the overall average to 78kg N/ha or 52 percent of the norm. The rate in Uzbekistan is double that in Kyrgyzstan for a smaller average yield indicating that it could be reduced for this level of productivity. Apart from cotton and wheat in Uzbekistan receiving 18 and 26 kg P/ha in Uzbekistan, or 26 and 58 percent of the norms respectively, very little of the irrigated land received much or any phosphate fertiliser. Almost no potassium fertiliser has been applied in Central Asia for several years and significant production may be being lost for this reason.

Water Resources, Management and Prices

It is not in the TORs of WUFMAS to study canal management, but records of the supply of water to the whole farm and the manner that it is used on a monthly basis are obtained from farm staff. An approximate account of water use and losses was compiled for each farm, making assumptions about the conveyancing efficiency of the canal system. As percent of headwater abstracted, about 37 percent is lost during delivery to the field boundary, most in Turkmenistan and least in Uzbekistan, which could be reduced only by heavy capital investment. As a result of poor canal management on the farm a further 23 percent is lost, but this was estimated to vary from 5 to 29 percent from Tadjikistan to Uzbekistan farms. As a result of poor water management in the field during irrigation, a further 21 percent is lost, varying from 14 percent in Kazakhstan to 37 percent in Tadjikistan. Overall, only about 20 percent of total water abstracted is retained in the rootzone for use by the crop, varying from 16 to 26 percent from Kyrgyzstan to Turkmenistan respectively.

The variation between regions and between farms in the use of water for crops is considerable. For cotton the range was between 5.7 and 14.0 thousand m^3 (tcm)/ha from Kazakhstan to Tadjikistan, the proportion used for leaching varying from 80 percent to none respectively. Average use on cotton is about 7.0tcm/ha including the leaching component, which is approximately equal to the estimated seasonal evapotranspiration (ETc). In-field application efficiency is very much less than 100 percent, so crops in places are benefiting from substantial capillary rise into the root zone from the watertable and in others suffering from overly long irrigation intervals that subject the crop to moisture stress and lose yield. There is a similar pattern in irrigation of wheat with an overall average use of 4.7tcm/ha, not much more than the evaporative demand.

On four Kazakhstan sample farms, an average of 4.6tcm/ha was used for leaching. The average root depth of cotton is only about 0.7m so the largest fraction of the leaching water is not retained there but drains to the groundwater raising the watertable by about 1.7m annually. As lateral drainage mostly is slow, excessive leaching is maintaining high groundwater and causing secondary salinity, the very problem it aims to control. Similarly, the cultivation of rice therefore is not so much a strategy for control of salinity but its cause.

The groundwater beneath 74 percent of sample fields was closer than 3m to the surface and in places is very saline. The daily contribution into the rootzone from this depth in the predominantly silty soils of Central Asia is considerable and profoundly affects the ideal irrigation schedule. Several models exist for estimating this contribution but estimates from local models and those quoted internationally differ substantially, suggesting that further work would be advisable. Recent improvements to Kharchenko's model predict an overall average daily contribution of 1.5mm/day, equivalent to about 2.2tcm/ha during the cotton season, rather more in Turkmenistan and Uzbekistan but almost none on the farms in Tadjikistan and Kyrgyzstan.

The international definition of the efficiency of application (E_a) of water in the field takes no account of drainage water re-use, but must include the groundwater contribution. Efficiency measured in sample fields was much lower than normative values, and this is a matter of great concern because excess irrigation, like leaching, raises the watertable and is a costly waste. Based on estimated crop evapotranspiration and seasonal water use in cotton fields, E_a was only about 39 percent overall, ranging from 70 percent in Kazakhstan to 27 percent in both Kyrgyzstan and Tadjikistan. The sample fields represented most combinations of slope and infiltration rate but the largest group (46 percent of fields) consisted of loamy soils with shallow and very shallow slopes. Only 11 percent of furrows were longer than recommended by the local methodology of Laktaev. Therefore, the main wastage of water in the field is by tail escapes from field canals and furrows, too long duration of irrigation and incorrect furrow flow rate. The reasons are believed to be lack of co-ordinated management, insufficient capacity in the system due to poor maintenance and the lack of incentives for operators to improve.

Until recently, no charge was levied for water for irrigation in Central Asia. A nominal charge is now made in all republics except Turkmenistan, ranging from $0.65 to $2.12/tcm from Tadjikistan to Kazakhstan. In Uzbekistan, the charge is collected along with other taxes levied on farms, and rarely is the water charge paid directly by the person responsible for water management. These financial prices for water are tiny by comparison with charges made in some countries and are only about 10 percent of the economic cost of water estimated by WARMAP in 1995, based on O&M and recapitalisation only.

Cotton and winter wheat were irrigated 3.4 and 3.7 times respectively on average during the season (excluding leaching) but there was considerable variation between farms. Crops were mostly irrigated once in Kazakhstan but cotton 7 times in Tadjikistan, because the former fields have a high watertable and the latter have steep, coarse soils. The evaporative demand of cotton is much greater than wheat indicating that, despite the groundwater contribution on many farms, there are too many instances of cotton being stressed as a result of the irrigation intervals being too long. Simulation suggests that where there is no groundwater contribution, 6-14 irrigations are required for cotton so that as much as 40 percent of cotton yield is being lost on such farms due to moisture stress.

Compensating for the wastage of water when the crop is irrigated, infrequent irrigation results in a total use of water that is approximately equal to the actual evaporative demand. Although potential evapotranspiration ($ET_{potential}$) in cotton is about 7.2tcm/ha, closure of the stomata during periods of moisture stress reduces actual evapotranspiration (ET_{actual}) to 5.7tcm/ha on average, or 79 percent of potential. This ratio for cotton varied from 95 percent on Kyrgyzstan farms to 56 percent on the sandy soils of the Tadjikistan farms where crops were more stressed. The effect of groundwater and moisture stress had marked effect on the productivity of water since in Kazkhstan, 2.33t of raw cotton and 1.53t of wheat were produced by one tcm of irrigation water compared with only 0.13t of cotton in Tadjikistan and 0.23t wheat in Turkmenistan.

Compared with international criteria (EC_w, chloride concentration and SAR), the salinity hazard of irrigation water appears greater when local conventions are used. Originating as snowmelt, the quality of irrigation water according to FAO criteria is mostly good, but discharge of drainage water into the rivers reduces quality in the lower reaches during summer, and drainage water and groundwater are used for irrigation where there is a localised shortage of water. Salinity of irrigation water therefore falls with rising altitude and is best in Kyrgyzstan and worst in the lower Amudariya. Calcium and magnesium are the predominant cations in irrigation water in all republics except Tadjikistan and potassium concentration is very low throughout. Everywhere, sulphate is the predominant anion and only 2 and 3 percent of samples in 1996 and 1997, mostly from Uzbekistan, were rated as hazardous on the basis of their chloride content. Although all samples were alkaline, the bicarbonate levels were not high except for some samples of moderate hazard from Kazakhstan in 1996. The sodicity hazard was serious in about 10 percent of samples from Uzbekistan in the dry season of 1996 but not in 1997, indicating considerable seasonal variation. The majority of drainage and groundwater samples were seriously saline with a significant sodium hazard, mostly from sodium sulphate but on the Turkmenistan farms from sodium chloride. Following irrigation of some Uzbekistan sample fields with drainage water of EC_w 2dS/m, the salinity of the topsoil more than doubled between 1996 and 1997.

Agronomic data

The sample farms are distributed between six agro-climatic zones and records of cotton growth have been summarised on this basis. Plant population in cotton was greater than 200,000 per ha after germination but after thinning and loss from root-rot, population stabilised in the range of 80 to 120 thousand plants/ha. Mostly in rows 0.9m apart, this population is very high by international standards but is a deliberate practice for maximising yield where the growing season, between early June and September, is very short for this crop. The development of rooting closely mirrored that of plant height cm for cm, height lagging slightly behind root depth in May and June, reaching equality in early July and moving slightly ahead thereafter until topping restricted shoot development. This was generally true except on the coarse soils of the Tadjikistan farms where roots were about 50 percent deeper than plants were tall. This observation is important as root depth is used in calculating the ideal irrigation schedule, to which it is very sensitive.

The onset of rapid vegetative growth in cotton is delayed by cool nights. The warmer spring of the southern zone promoted more rapid growth of cotton from early June, but it was delayed until early July at high altitude, these plants growing taller by the end of August. With more rapid growth, cotton flowering began in early June in the south but in most areas in late June, with most flowers opening at the end of July. The rapid fall in temperature from September limits development of later bolls, so that the majority of the revenue from cotton derives from the first set bolls that are larger and of better fibre quality. The number of open bolls rises to an average of 7 per plant by the end of October so that with 110,000 plants per ha and an average boll weight of 3.3g, an average yield of 2.5t/ha was recorded in the sample plots.

Weeds, Pests, Diseases and their Control

Only rarely were agro-chemicals used in sample fields to control weeds, pests or diseases. In the early season, weeds were as numerous as cotton seedlings, but by June, with only a few exceptions, weeds were well controlled by hand-weeding and interrow cultivation, numbers being generally less than one percent of the number of cotton plants. Competition from weeds in the early stages may be more serious, but in only few fields was there evidence of crop loss due to weeds uncontrolled by June.

Eleven pest species and three diseases were recorded on cotton: American bollworm, spider mite, aphid, leaf-eating caterpillars and cutworms being the most common. Leaf-eaters appeared in early May causing quite serious damage in June, followed shortly after by cutworms and aphids, and later by mites and bollworms. The first damage from American bollworm was reported in June, rising in intensity thereafter but reaching a serious level in only 8 percent of fields assessed. Damage from spider mite and aphid was rarely serious. Loss of seedlings from root-rot was commonly reported and was quite serious during wet, cold weather in May, but damage from Verticillium was not. Thirteen pest species, four fungal diseases and one virus were reported in winter wheat, with mildew, stem rust, haplothrips, aphid and leaf beetles being the most common. Some pests and stem rust appeared before flowering but most in April, with damage rising into May in some cases at moderately severe levels. Seventeen insect pests were recorded on lucerne crops but no diseases, and of these the lucerne beetle, aphids and sucking bugs were the most common, all causing moderate to fairly serious damage in most months of the season. Where it appeared, the lesser army worm cause moderately severe damage in lucerne and American bollworm was reported to be causing moderate damage in August in two fields. Control measures for American bollworm in cotton may need to be extended to lucerne.

No herbicides were used in the cotton sample fields. The overall average use of herbicide on wheat was only 2 percent of the norm, mostly on a few fields in Kyrgyzstan at 1.5kg/ha where the crop was for seed. However, about half of the fields of rice were treated at about 3kg/ha.

Overall, only 28 percent of the normative rate for insecticide was used in cotton. All cotton fields in Kyrgyzstan were sprayed to control insects at an average rate of 5.1kg/ha, but the proportion was much less in other republics and much lower rates were used. No insecticide was used in Turkmenistan. Insecticides were rarely substituted by release of biological control agents as this was at only 20 percent of the norm overall, restricted to all cotton fields in Kazakhstan and a few in Uzbekistan. A small quantity of insecticide was used on wheat in Kyrgyzstan on average at only 6 percent of the norm and although two out of three lucerne crops in Uzbekistan were sprayed the rate of application was very low, suggesting spot spraying.

Twenty three percent of cotton fields in Kyrgyzstan were treated with fungicide at an average rate of 7kg/ha, and some was applied to wheat but the overall rate, as percent of the norm was negligible. Some growth regulator was applied in a few fields of cotton in Kazakhstan at 2.1kg/ha on average. Defoliant (magnesium chlorate) was applied to assist maturation and harvesting in all cotton fields in Kazakhstan and Kyrgyzstan and in one third of fields in Uzbekistan at average rates from 7 to 14kg/ha.

Most agro-chemicals used in the region are off-patent products and are not expensive. Most international producers are represented in the region and their modern products that have been registered are relatively expensive and sales are insignificant at present.

Machinery and Labour Use and Prices

Formerly, there was a policy of heavy mechanisation of crop production with large numbers of machines of a wide range of types being supplied to farms in the FSU. This reflects in the norms, which are high by international standards. Lack of replacements for ageing machines, fuel and spare parts has restricted actual machinery use to about one third of the norms overall, and much closer to western standards. The norms for tractor use vary somewhat between republics, but are about 53 and 30h/ha for cotton and winter wheat respectively. In practice, farms achieve about 40 percent of the norms in cotton, 30 percent in wheat, 38 percent in lucerne and 19 percent in rice.

The real financial price of running tractors and implements may be greater than perceived, with average hourly operating costs estimated to be about $13 for land preparation, $8 for seedbed preparation, crop and post-harvest operations, and $16 for specialised harvesting machines. These prices are well below international values on account of the low capital price of machines on the local market, the low imputed cost of labour and improvisation in the maintenance of machines.

Rural communities generally have been unwilling to respond in full to the demand created by the shortage of machinery, mainly due to the inability of many farms to be able to pay cash for labour. Notional wage rates have been used in the estimates of variable costs, but they are mostly imputed since payment for labour is mostly made in the form of commodities, access to land for private use and in the common services provided to resident families. These notional rates range from $44 to $3.4 per man-month between Kazakhstan and Tadjikistan and in $ terms are mostly less than in 1996 due perhaps to exchange rate.

The labour norm for cotton is about 121 mandays/ha but actual use varied from 18 percent to 186 percent of this, from Kazakhstan to Kyrgyzstan, the former reflecting privatisation with mechanical harvesting and the latter privatisation, fragmentation of land and little use of machinery. The range for wheat was much smaller, from 8 to 69 percent of the norm of 13 mandays/ha, from Kazakhstan to Turkmenistan. Norms for labour use in crop production should be seen in the context of the heavy norms for machinery use, and are very high by international standards. For comparison, about 8-10 tractor-hours and 15 man-hours of labour produce an average yield of wheat of 8t/ha in U.K.

Crop Yields and Prices

Although 20 different crop types and two mixed crops were sampled in 1997 in WUFMAS fields, 86 percent of them were under only four crops so reliability of estimates for these is much greater than the others. The average yields of upland cotton, lucerne, rice, and winter wheat were 2.3, 31.2, 3.6 and 2.3t/ha respectively. Compared with 1996, the yields of cotton and lucerne were much the same, rice was better and wheat poorer, but there was considerable variation between farms and fields.

Most farmgate economic crop commodity prices are close to their estimated financial equivalents since few are internationally traded. The noteworthy exceptions are cotton and wheat in the command economies of Turkmenistan and Uzbekistan, where the farmgate financial price of raw cotton at $245/t is hardly more than half of the economic price of $450-$475/t, based on an average export parity price of fibre. The price in Kyrgyzstan at $493/t is somewhat greater than the export parity price and may reflect better fibre quality. The financial price of wheat grain in these republics at $84 and $121/t respectively, is only 26 and 38 percent of an import parity price from world markets, but they are about 65 and 93 percent of the farmgate export parity price from Kazakhstan of $130/t. At $140/t, the price of wheat on the farms in Kazakhstan and Kyrgyzstan is slightly more than the estimated export parity price of rainfed wheat, and this may reflect a quality premium. The wheat price of $99/t estimated for Tadjikistan may have been affected by the rapid devaluation of the Tadjik currency. Rice paddy sells from Uzbekistan farms at $283/t, some 35 percent above an import parity price of Thai rice maybe on account of local quality preference, but the farmgate price in Kazakhstan is slightly below it. Fodder crops are difficult to price as they are rarely traded. Prices are certainly low, reflecting the poor transfer price to livestock enterprises whose output prices in turn are low on account of the low public purchasing capacity. Fodder prices seem insensitive to their feed value and moisture content.

Variable Costs of Production and Taxation

The strict western definition is used: a cost that is directly related to the production of an enterprise (a crop) that would not be incurred if the enterprise were not produced. The costs of management, administration, marketing produce, maintaining the infrastructure of the farm, power (except fuel for tractors and harvesters) and direct taxes are farm overhead or fixed costs and are excluded from variable costs. Some of the fixed costs are included with “variable costs” in current farm accounting practice. There is a major contribution made by the farm to the upkeep of the local community, a part of which is a legitimate component of the imputed cost of labour used as both fixed and variable costs of the farm.

Estimates of total variable cost per ha at financial prices ranged from $27 for a mature apricot orchard to an average of $547 for rice, with cotton and wheat at $376 and $322. Variable costs tended to be highest in Uzbekistan on account of the greater use of machinery and fertiliser, which was not matched by greater crop yields. The averages over all crops sampled showed that machinery is by far the largest component variable cost, about 60 percent of the total. This ranged from 0 to 90 percent in different crops, but the proportion for major crops varied from 79 percent in lucerne to 55 percent in cotton. The remaining variable costs were fairly evenly spread amongst the other factors of production, with agro-chemicals and water the smallest, but considerable variation between crops. After machinery, the next largest cost was for labour in cotton (18%), water in mature lucerne (8%), seed (15%) and fertiliser (10%) in rice, and seed (25) in wheat. Tobacco grown in Kyrgyzstan had the most extreme distribution of component costs with only 13 percent for machinery, and about 25 percent for each of labour, seed and water.

The WUFMAS survey has been unable so far to make estimates of the farm overhead costs and community charges. The largest taxes in the region are the indirect taxes on production represented by the big difference between the financial and economic farmgate prices of cotton and wheat in Turkmenistan and Uzbekistan, more than $500 per ha of cotton on average. All farms pay direct taxes but as they are levied as percentages of notional farm book values, they vary from farm to farm. An example farm in each republic was studied and the total direct tax liability expressed per ha of irrigated land ranged from $11 in Tadjikistan to $51 in Uzbekistan.

Crop Gross Margins

This measure of the contribution that a crop makes to the profitability of the farm is strictly defined as the margin between the gross output (revenue) of the crop and its total variable cost and is calculated per ha as a return to land. Alternatively it is expressed as a return to physical inputs such as a unit of water used to produce the crop, as a financial return on the investment in a particular input, and as a return to the annual investment in the crop (benefit:cost ratio). Gross margins at economic prices have not been calculated as in the 1996 report, but financial crop budgets have been calculated for the crop in every sample field rather than by using average inputs for each republic as in 1996. Crop budgets averaged over all the fields of each crop on each farm are given in Appendix 7.

Cotton is again outstandingly the most favourable crop for bulk production in the area, despite the heavy tax on production in Turkmenistan and Uzbekistan. Either upland or pima cotton, or both, ranked in the top three crops in all republics with very attractive financial gross margins from $356 to $819 per ha. Rice grown in Kazakhstan and Uzbekistan had a robust gross margin making it an attractive crop for production in appropriate locations. The gross margins of perishable commodities, fruit and vegetables, can vary widely in relation to market demand and the selling price, but their market capacity will remain small without the development of processing facilities and efficient export marketing. Maize grown for grain performed somewhat better in Uzbekistan in 1997 due to improved yield raising the prospect of some potential of this crop if yield could be improved consistently. Tobacco and sugarbeet performed particularly well in Kyrgyzstan as a result of buoyant prices, but the sustainability of the price quoted for beet is questionable. Market prices of fodder crops mostly limit their gross margins, but yields and prices reported in Kazakhstan and Turkmenistan were high enough to elevate the gross margin of lucerne there to a respectable place in the crop rankings. Maize and sorghum grown for silage after harvest of winter wheat had negative gross margins and the role of this type of fodder crop on the farm should be questioned. The same is true of winter wheat and other small grain cereals, which mostly ranked low with small positive or negative gross margins. The exception was winter wheat in Kyrgyzstan where a combination of higher yield and price gave the crop an acceptable return to land.

It is argued that there is a crisis in the availability of cash to purchase the inputs for crop production so that ranking of crops on the basis of their benefit:cost ratio is more important than their return to land. Ranking of the crops in this way somewhat changed the priorities, but the conclusions given above are not greatly changed. Cotton remains unassailable as the pre-eminent crop for the area but on account of its high production cost, ranks less highly than certain other crops such as maize for grain. Tobacco and sugarbeet remain attractive but are joined by green gram. Rice is less favourable and lucerne gives mixed results, but winter wheat fails to improve its position and is a questionable crop for the area without a very large increase in productivity.

Conclusions

- Farm profit is determined by the total gross margin of all the enterprises, the size of the overhead costs and the level of direct taxation, and could be improved, but WUFMAS has not yet measured the size of farm overhead costs nor the efficiency with which these resources are used, and therefore is unable to make recommendations on the contribution that improved efficiency might make to increasing farm profitability;

- Overall gross margin of crop enterprises could be markedly increased on Central Asian farms by maximising the marketable area of the crops with the highest benefit:cost ratios while reducing or eliminating the production of crops with small and negative returns;
- Improved management of crop production, particularly in regard to the timeliness of operations, and scheduling of irrigation, could significantly increase the yield of crops without greatly increasing either the variable or overhead costs of the farm;
- Judiciously increased use of pesticides (within an effective IPM programme), and increased use of P and K fertilisers generally, and N fertiliser on some farms and some crops (paid for out of savings in reduced use N fertiliser applied to cotton and wheat and machinery in general), could increase crop yields without greatly adding to the variable costs of production;

- Salinity is not as serious as believed but may get worse if abuse of water is not checked;
- A big improvement in overall efficiency of water use in agriculture would require heavy capital investment, but modest improvement in management of on-farm canals and in-field application during leaching and irrigation is possible by limiting supply where use is excessive, and without greatly increasing costs, except for training and payment of cash incentives to operators.