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# MIXED FARMING SYSTEMS IN TRANSITION: THE CASE OF FIVE VILLAGES ALONG A RAINFALL GRADIENT IN NORTH-WEST SYRIA

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SUMMARY

The changes taking place in the mixed farming systems of northwest Syria were examined by re-visiting, in 1996 and 2000, five villages along a rainfall gradient. The villages had been surveyed first in 1977–79. In those villages with moderate rainfall, intensification of crop production, namely a trend towards cereal monoculture and the planting of tree crops, did not lead to specialization in cropping at the expense of sheep ownership. In contrast, households in the areas too dry for most rainfed crops except barley (*Hordeum vulgare*) were more likely to sell their sheep because they depended heavily on off-farm income. Increases in crop yields were found but these only benefited the families in villages in the higher rainfall zones. Conversely, with the exception of ewe fertility, there was little evidence of improvements in sheep productivity. The mixed farming systems in the five villages sampled are still passing through a period of transition, and the cropping component will undoubtedly continue to change. This is less likely to happen to the small ruminant component in the near future unless the sector is given higher priority in national policy. As a strategy to increase feed production and balance the crop rotations, the prospects for closer crop/livestock integration at the farm level are limited by the many difficulties associated with the introduction of leguminous pasture and forage crops.

## INTRODUCTION

Mixed farming systems predominate in the semi-arid areas of West Asia and North Africa (WANA). Syrian agriculture, like that in many other countries in WANA, is passing through a period of transition that started in the late 1950s. The transition has been strongly influenced by government policy that has adopted a strategy of agricultural intensification since 1975 (AOAD, 1975). Subsidies and loans to drill wells to enable the production of irrigated crops were offered to farmers and a fruit tree promotion programme for land unsuitable for field crops was launched (Pape-Christiansen, 2000). Fertilizer was also subsidized, the subsidies accounting for, respectively, 30 % and 49 % of the true costs for urea and phosphate in 1989/90 (Saade, 1991). The more than two-fold increase of the agricultural gross domestic product per ha from 1980 to 1996 indicates that at the national level agricultural

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intensification has been successful (MEDAGRI, 1999). Also, the output of fresh cow milk nearly trebled in the 20 years to 1996, even though numbers of dairy cows remained stable (FAO, 1997).

Compared with the cropping and dairy sectors in Syria, small ruminant management practices changed very little and productivity remained static (FAO, 1997). Most of the increased output of sheep meat and milk resulted from the higher animal population, itself a consequence of policies that encouraged the liberal use of hand-fed feeds in winter. Moreover, the considerable amount of research that aimed to increase the feed supply by what is termed 'improved crop-livestock integration', had little impact. In the higher rainfall areas, improved integration would be achieved through the introduction of annual pasture legumes (*Medicago* species, or medics) into wheat-dominated crop rotations (Christiansen *et al*., 2000a). In the lower rainfall areas it would be achieved by introducing annual forage legumes such as common vetch (*Vicia sativa*) into the cropping system dominated by barley (Thomson *et al*., 1992; Christiansen *et al*., 2000b).

One question that arises concerns the extent to which the apparent intensification of crop production has been accompanied by changes to the small ruminant component of the mixed farming systems. To address this question surveys were carried out in 1996 in northwest Syria where the International Center for Agricultural Research in Dry Areas (ICARDA) had conducted studies of farming systems 19 years earlier (ICARDA, 1980). The surveys targeted a sample of households in five villages situated along a transect with a steep rainfall gradient and contrasting farming systems. Follow-up visits in 2000 helped to interpret the results collected during the formal interviews. Information was collected about the changes in land and water use, crop productivity, off-farm employment and the small ruminant component of the mixed farming systems.

This paper presents the results from the surveys in the five villages and attempts to explain the reasons for the changes to the mixed farming systems. The findings are pertinent to the debate about whether crop-livestock integration at the farm level is a useful concept for both intensifying production and sustainable use of natural resources (Tutwiler *et al*., 1997). The paper ends by indicating the future prospects for crop, tree crop and livestock production under the changing circumstances in the respective zones and suggests some research issues that need to be addressed.

## MATERIALS AND METHODS

### *Characteristics of the study area*

The study area covers Aleppo Province in northwest Syria where different farming systems are found in the agricultural zones that cross a 100 km rainfall gradient. The zones are largely the consequence of the marked decrease in the rainfall from over 600 mm each year in the north-west to less than 200 mm in the south-east where the steppe begins. However, over the last 19 years improved roads, better transport, more access to water for irrigation in many areas, and the firm demand for fresh food products due to the proximity of Aleppo, have contributed to the evolution of the farming systems. The climate in Aleppo Province is Mediterranean, with cool winters, a rainy season in winter and spring, and hot, dry summers.

The main characteristics of the rainfed-based, mixed farming systems located in the four agricultural zones[1] that cross the rainfall gradient are summarized in the following paragraphs. They are presented as they were in the late 1970s, starting in the north-west where the rainfall is highest (ICARDA, 1980):

i. Cereals, olives, legumes and summer crops and small ruminants were found in Zone 1, and a few households owned a dairy cow. The dominant crops were winter-sown wheat (*Triticum* spp.), olives (*Olea europaea*), spring-sown chickpeas (*Cicera arietinum*) and summer crops such as watermelons (*Citrullus vulgaris*), which were grown on land left fallow in winter. Smaller areas of lentils (*Lens culinaris*) were grown. Crop rotations were variable, but dominated by wheat. Village 1A in the sample is located in this farming system.
ii. Cereals, legumes, summer crops and small ruminants were found in parts of Zone 1 and the higher productivity areas of Zone 2. The main crops were wheat, lentils and watermelons, and in the drier areas of Zone 2 barley replaced lentils and wheat or the land was left fallow. Forage legumes such as vetch, various fruit and nut tree-crops (olives, grapes (*Vitis vinifera*), pistachios (*Pistacia vera*), almonds (*Prunus amygdalus*), figs (*Ficus carica*)) and some summer crops were also grown. Villages 2A and 2B are found in the areas where these crops are grown.
iii. Cereals, substantial areas of fallow, legumes and considerable numbers of small ruminants, were found in the low productivity areas of Zone 2 and in Zone 3. Barley was the main cereal crop, with some inclusion of lentils and forage legumes. Summer crops were planted on deep soil in years with above average rainfall. Village 3 is situated in this farming system.
iv. Cereals, dominated by barley, and fallow were found in the poorer areas of Zone 3 and in Zone 4, and small ruminants were important. Wheat was also grown, but no summer crops and legumes were grown due to the low rainfall. Village 4 is located in this farming system.

In the late 1970s in the villages studied, cereal crops sometimes received supplemental irrigation, and full irrigation was applied to faba beans (*Vicia faba*), cotton and summer crops such as vegetables using water from privately owned wells.

The predominant sheep breed in the study area is the fat-tailed Awassi. Apart from the changes reported later in the paper, the annual breeding and feeding calendar only changed marginally over 19 years. It has three phases, which are largely the consequence of the main climatic and cropping events:

– October – February when most ewes are pregnant and give birth to a single lamb and sometimes twins. Hand-fed cereal straws, barley grain and agro-industrial by-products are offered and grazing of residues of irrigated cotton and vegetable crops,

[1] The agricultural stability zones in Syria are defined elsewhere (MAAR, 2001).

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Table 1. Characteristics of the five villages in the sample in 1977, the number of households in the surveys and the indicative annual rainfall in the villages.

| | Characteristics of the five villages (ICARDA, 1980, Section 2, Appendix 1) | | | | Number of households in the surveys | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | General surveys | | Detailed surveys | | |
| Village code[†] | Total population | Total area (ha) | Head of small ruminants | Number of households | 1977 | 1996 | 1977–79 | 1996 | Indicative annual rainfall[‡] |
| 1A | 290 | 400 | 440 | 46 | 39 | 22 | 7 | 7 | 500 |
| 2A | 350 | 520 | 350 | 45 | 39 | 22 | 8 | 6 | 331 |
| 2B | 400 | 1255 | 1400 | 55 | 46 | 23 | 8 | 6 | 303 |
| 3 | 1300 | 1323 | 2500 | 75 | 64 | 29 | 13 | 11 | 289 |
| 4 | 300 | 618 | 550 | 30 | 30 | 20 | 10 | 6 | 222 |
| Total | – | – | – | 251 | 218 | 116 | 46 | 36 | – |

[†]These codes refer to the agricultural stability zones in Syria, as defined by MAAR (2001).
[‡]As there are no long-term rainfall records for the five villages, these indicative values are taken from ICARDA (1980, Table 3.1, page 30). Rainfall is the total for the cropping season, 1 September to 31 August. Only in the 1978/79 cropping season was the rainfall markedly lower than the indicative values across the five villages.

sparse communal village pastures, field boundaries and fallow, takes place. Hand feeding continues into March if the rains are poor or the winter particularly cold.

– March – May when lambs are weaned at the age of two-to-three months and then ewes are milked. The new growth of the sparse vegetation on the communal areas surrounding the villages is grazed and some households move with their flocks to the steppe.
– June – September when lactation ends and most ewes are mated. Cereal stubble in the villages is the main feed resource but households sometimes move with their flocks to other areas to rent stubble for their animals, collect straw to feed in winter and to find work.

*Data collection*

Monitoring in the five villages took place during two phases separated by 19 years. Each phase involved a general survey and a detailed survey. The general survey in 1977 collected baseline data from a high proportion of the farming households in the villages (Table 1). From among these households a representative sample was selected for a detailed survey. It involved monthly visits by members of a multi-disciplinary team to 46 households for two cropping seasons, 1977/78 and 1978/79 (ICARDA, 1980). In the spring of 1996 as many as possible of the households included in the original general and detailed samples were visited on two occasions. Whenever possible the same farmers as in 1977–79 were interviewed. If the original informant had died or left the village, the person, generally a close relative, who had taken over the land and the animals was questioned. When adult sons and daughters were still working together with the father on the same land, they were considered part of the household. When land was distributed before the death of the father, and sons operated the land independently, they were considered to be separate households.

To verify the results from the comparative analysis and to explore certain aspects in greater depth, the five villages were visited again in July 2000. Group discussions were held in Villages 2A and 2B, whereas in the other three villages the majority of the families in the sample were temporarily absent. Key informants, such as heads of villages and local extension officers, and individual farmers who were found to have made a major change to their production system, were interviewed to verify the findings and to discuss the reasons for the changes.

Interviewers used structured questionnaires except in 2000 when open-ended questions were asked. The general survey in 1996 covered the same questions as those asked in 1977, such as the areas of annual and tree crops, ownership of sheep, goats, dairy cows, poultry, tractors and wells, and off-farm employment. The detailed survey in 1996 included the same questions that were asked during the monthly visits in 1977–79, including:

– Areas and yields of rainfed and irrigated annual crops and areas of tree crops.
– Numbers of adult and yearling male and female sheep and goats.
– Ewe milk yield after weaning of lambs at two-to-three months of age.
– Ewe fertility and ewe and lamb mortality.
– Annual feeding calendar – based on the main grazing resources and hand-fed feeds.
– Amounts of hand-fed feeds offered in winter and spring.

Grain yields, estimated by farmers as the number of bags harvested, represent the harvests in the summers of 1978, 1979, 1994 and 1995, whereas the ewes' performance data cover the 1977/78, 1978/79, 1994/95 and 1995/96 breeding seasons.

*Data analysis*

Changes over 19 years in the numbers of households growing annual crops, owning tree crops, a well, a tractor, ruminants and poultry, and working off-farm, were assessed for deviations from the expected frequencies using $\chi^2$ (Table 2). Results concerning the areas of rainfed and irrigated annual crops, tree crops, crop yields, sheep, goat and poultry inventories, measures of ewe productivity and amounts of supplementary feeds offered, were analysed using the GLM procedure of SAS Version 6.12, with the data from three or four years being included as repeated measures. Thus, the changes were compared within the households. The model tested for the effect of year and village and the interaction between year and village within farms. In the first GLM analysis households from the general surveys that cultivated crops and owned tree crops, small ruminants and poultry were compared (Table 3). In the second analysis the crop areas, ewe productivity and amounts of supplementary feed were analysed for the households sampled in the detailed surveys (Table 4, 5 and 6). The standard deviations (*s.d.*) shown in the tables are derived from the square root of the error mean square. The total amount of metabolizable energy (ME) offered to the flocks (Table 6) was derived by summing the amount provided by each feed, using ME values from different sources (ICARDA, 1980; Close and Menke, 1986).

Table 2. Number of households growing rainfed and irrigated crops, owning tree crops, a tractor, a well, small ruminants, dairy cows and poultry, and employed off-farm. (General surveys.)

| | | Year effects | | Village effects by year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1A | | 2A | | 2B | | 3 | | 4 | |
| | | 1977 | 1996 | 1977 | 1996 | 1977 | 1996 | 1977 | 1996 | 1977 | 1996 | 1977 | 1996 |
| Households growing | Rainfed crops | 116 | 113 | 22 | 21 | 22 | 22 | 23 | 23 | 29 | 27 | 20 | 20 |
| | Irrigated crops | 3 | 25 | 0 | 3 | 0 | 2 | 3 | 10 | 0 | 1 | 0 | 9 |
| | Tree crops | 44 | 57 | 20 | 20 | 12 | 16 | 12 | 19 | 0 | 2 | 0 | 0 |
| Ownership of a | Tractor | 11 | 26 | 4 | 8 | 6 | 9 | 1 | 5 | 0 | 3 | 0 | 1 |
| | Well | 5 | 74 | 0 | 11 | 0 | 18 | 5 | 19 | 0 | 18 | 0 | 8 |
| Ownership of | No sheep/goats | 6 | 23 | 1 | 10 | 1 | 2 | 2 | 0 | 1 | 6 | 1 | 5 |
| | Sheep alone | 36 | 21 | 3 | 1 | 4 | 4 | 11 | 5 | 12 | 6 | 6 | 5 |
| | Goats alone | 10 | 12 | 6 | 7 | 0 | 0 | 0 | 1 | 2 | 2 | 2 | 2 |
| | Sheep/goats | 64 | 60 | 12 | 4 | 17 | 16 | 10 | 17 | 14 | 15 | 11 | 8 |
| | Dairy cows | 4 | 4 | 3 | 0 | 0 | 1 | 0 | 1 | 1 | 2 | 0 | 0 |
| | Poultry | 105 | 56 | 21 | 6 | 21 | 15 | 22 | 15 | 21 | 11 | 20 | 9 |
| Off-farm employment | Farmer | 72 | 38 | 13 | 4 | 13 | 4 | 13 | 6 | 22 | 13 | 11 | 11 |
| | Other family members | 19 | 84 | 2 | 13 | 1 | 14 | 9 | 18 | 3 | 22 | 4 | 17 |

## RESULTS

### *Changes based on the general survey*

The number of households in the aggregated sample growing rainfed crops changed little over time. But there were significant increases in the number of households growing irrigated crops ($\chi^2 = 19.66$, $p = 0.001$) and owning a tractor ($\chi^2 = 7.24$, $p = 0.007$) and a well ($\chi^2 = 91.38$, $p = 0.001$) (Table 2). These increases varied from one village to the next. With the exception of Village 2B, none of the households were growing irrigated crops in 1977 but in 1996 many were, particularly in Villages 2B and 4. Consequently, well ownership was widespread in all the villages by 1996, whereas in 1977, apart from a few households in Village 2B, none of the households in the sample owned a well. Although more households owned tree crops in 1996 than in 1977, mainly due to the 58 % increase in tree crop ownership in Village 2B, the difference was not statistically significant ($\chi^2 = 2.96$, $p = 0.085$). With time, tractors also became more common in the villages in the higher rainfall zones, and in the drier villages some farmers started buying a tractor.

Averaged across the total sample, the area of cropped land per household decreased significantly ($p = 0.001$) by a third over 19 years, due to large reductions in Villages 2B and 3 (Table 3). In the former village deaths of fathers resulted in land being distributed between sons, and by 1996 some ageing fathers had already started to distribute land. In Village 3 a substantial area of land was given to a state enterprise. Areas per household of land under irrigation ($p = 0.001$) and tree crops ($p = 0.045$) increased from low levels in 1977 to seven and 16 % of the total cropped area, respectively, in 1996.

Substantial changes in ruminant ownership occurred (Table 2). In the general survey in 1977, 95 % of the households owned small ruminants, with mixed flocks being twice

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Table 3. Least square means of the areas of total land under crops, irrigated crops and trees crops and of the inventories of sheep, goats and poultry per household, averaged across the five villages and for each village in 1977 and 1996, for households growing crops and owning small ruminants and poultry in both 1977 and 1996. Values in parenthesis show the number of households used in the GLM analysis. (General surveys).

| | Year effects | | | Village effects by year | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1A | | 2A | | 2B | | 3 | | 4 | | |
| | 1977 | 1996 | *s.d.*† | 1977 | 1996 | 1977 | 1996 | 1977 | 1996 | 1977 | 1996 | 1977 | 1996 | *s.d.*† |
| Total cropped land‡ (ha) | 18.1 | 13.1 | 5.98 | 12.8 | 13.0 | 13.8 | 12.5 | 25.5 | 15.8 | 17.9 | 7.6 | 20.2 | 18.4 | 12.87 |
| | (113) | | | (21) | | (22) | | (23) | | (27) | | (20) | | |
| Irrigated crops§ (ha) | 2.0 | 3.9 | 1.38 | 0 | 8.0 | 0 | 2.4 | 2.0 | 2.2 | 0 | 5.0 | 0 | 4.4 | 1.40 |
| | (3) | (25) | | (0) | (3) | (0) | (2) | (3) | (10) | (0) | (1) | (0) | (9) | |
| Tree crops (ha) | 3.5 | 5.9 | 4.08 | 4.9 | 9.2 | 2.3 | 2.8 | 2.6 | 3.6 | – | – | – | – | 5.77 |
| | (40) | | | (18) | | (12) | | (10) | | – | | – | | |
| Sheep inventory | 25.1 | 29.9 | 24.06 | 20.0¶ | 83.3¶ | 17.7 | 23.6 | 35.5 | 15.6 | 28.3 | 44.3 | 15.7 | 17.9 | 27.47 |
| | (74) | | | (5) | | (19) | | (20) | | (19) | | (11) | | |
| Goat inventory | 6.1 | 6.3 | 3.72 | 10.8 | 15.1 | 5.4 | 3.5 | 5.1 | 4.0 | 6.1 | 6.4 | 2.4 | 1.8 | 5.87 |
| | (49) | | | (10) | | (12) | | (9) | | (10) | | (8) | | |
| Poultry inventory | 25.7 | 14.3 | 11.80 | 14.2 | 6.5 | 27.3 | 16.7 | 44.0 | 12.1 | 16.9 | 21.5 | 8.2 | 12.6 | 11.60 |
| | (53) | | | (6) | | (15) | | (15) | | (8) | | (9) | | |

†Standard deviation derived from the square root of the error mean square.
‡Includes land under rainfed and irrigated crops but excludes land under tree crops.
§Means include all households growing irrigated crops in the respective year; *s.d.* and significance derived using complete sample ($n = 116$) since most households were not growing irrigated crops in 1977.
¶Excluding the one farmer who became a sheep trader and whose inventory increased from 20 to 207 between 1977 and 1996, results in means of 20.0 and 52.4 respectively.

as popular as sheep alone. Over the 19 years there was a large increase in the number of households in the sample owning no small ruminants since many farmers sold their sheep ($\chi^2 = 11.39$, $p = 0.001$). Small ruminant ownership mainly decreased in Villages 1A, 3 and 4. Ownership of goats alone was only common in Village 1A. Averaged across the whole sample, the mean ownership of sheep per household ($p = 0.01$), but not of goats, increased over time, since by 1996 the sheep flocks in Villages 1A and 3 were much larger (Table 3). By contrast, sheep ownership per household decreased in Village 2B over the same period. Only in Village 1A was there a substantial increase in the goat inventory per household.

Only four of the households in the general survey kept dairy cows in both 1977 and 1996, but the small changes with time varied from village to village (Table 2). The visit in 2000 indicated that dairy cows are becoming more important in Zone 2 since there is a well supported government-run artificial insemination service in the area and a good collection and transport system to deliver milk to Aleppo city.

Averaged across the whole sample, most households in 1977 owned poultry but by 1996 ownership had decreased by 46 % ($\chi^2 = 48.73$, $p = 0.001$, Table 2). Those households in Villages 1A, 2A and 2B that kept poultry in 1977 owned fewer in 1996 (Table 3). However, the opposite trend was seen in the two more remote villages in

Table 4. Numbers of households growing crops each year, and least square means of the areas of tree crops and of rainfed and irrigated crops grown by each household. Data from all 36 households were used in the GLM analysis. (Detailed surveys).

| | Numbers of households growing crops each year | | | | Areas of crops grown each year (ha household$^{-1}$) (n = 36) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 77/78 | 78/79 | 93/94 | 94/95 | 77/78 | 78/79 | 93/94 | 94/95 | *s.d.* |
| Tree crops | 12 | 12 | 15 | 15 | 2.0 | 2.2 | 2.9 | 2.9 | 2.45 |
| Barley (rainfed) | 31 | 32 | 25 | 24 | 6.6 | 6.1 | 6.1 | 5.0 | 3.00 |
| Wheat (rainfed) | 35 | 31 | 15 | 16 | $6.2^{a\dagger}$ | $5.6^{a}$ | $1.4^{b}$ | $1.4^{b}$ | 3.54 |
| Lentil (ha) | 18 | 15 | 7 | 7 | 1.2 | 1.4 | 0.6 | 1.2 | 3.41 |
| Barley (irrigated) | 0 | 0 | 5 | 6 | $0^{a}$ | $0^{a}$ | $0.3^{b}$ | $0.5^{b}$ | 0.57 |
| Wheat (irrigated) | 0 | 0 | 8 | 8 | $0^{a}$ | $0^{a}$ | $0.6^{b}$ | $0.7^{b}$ | 0.74 |
| Chickpeas | 7 | 5 | 3 | 1 | $0.9^{a}$ | $0.7^{ab}$ | $0.3^{bc}$ | $0.02^{c}$ | 0.91 |
| Vetch | 7 | 3 | 0 | 0 | $0.2^{a}$ | $0.1^{b}$ | $0^{c}$ | $0^{c}$ | 0.15 |

$^{\dagger}$Means in rows followed by different superscripts are significantly different at $p < 0.05$.

the driest areas. These changes are related to the better availability of commercially produced eggs and poultry meat in the Aleppo and other bazaars.

The number of farmers involved in off-farm employment halved during the 19 years ($\chi^2 = 19.99$, $p = 0.001$), with marked decreases seen in each village except Village 4 (Table 2). Conversely, in all villages more of the other members of the families in the sample started in this period to work off-farm ($\chi^2 = 73.77$, $p = 0.001$). This finding is due partly to the ageing of the adults in the villages over the 19 years, and partly because the children are gradually joining the workforce.

*Changes based on the detailed surveys*

In 1977–79 most of the 36 households in the detailed survey were growing rainfed barley and wheat, half of them were growing lentils, a third owned tree crops and 20 % were growing chickpeas and vetch (Table 4). At that time, however, none of the households in the sample were growing irrigated barley and wheat. Substantial changes occurred during the following years. The number of households growing rainfed crops decreased by 22 % in the case of barley and by about 50 % in the case of wheat and lentils, nearly all households stopped growing chickpeas and all households stopped growing vetch. In contrast, about a fifth of the households started growing irrigated barley and wheat (Table 4), and most of them were in Village 4.

In terms of cropped area per household averaged across the whole sample, in 1977 rainfed barley and wheat were the two most important crops, followed by tree crops, lentils and chickpeas and a small area of vetch (Table 4). Over the next 19 years the ownership of tree crops and the average area of rainfed barley and lentils grown by each household remained stable. The areas of rainfed wheat and chickpeas, however, decreased substantially and vetch was no longer grown. Some farmers began growing modest areas of irrigated barley and wheat.

A closer examination of the data reveals a more complex picture at the village level. Tree crops were owned by most of the households sampled in Villages 1A, 2A and 2B,

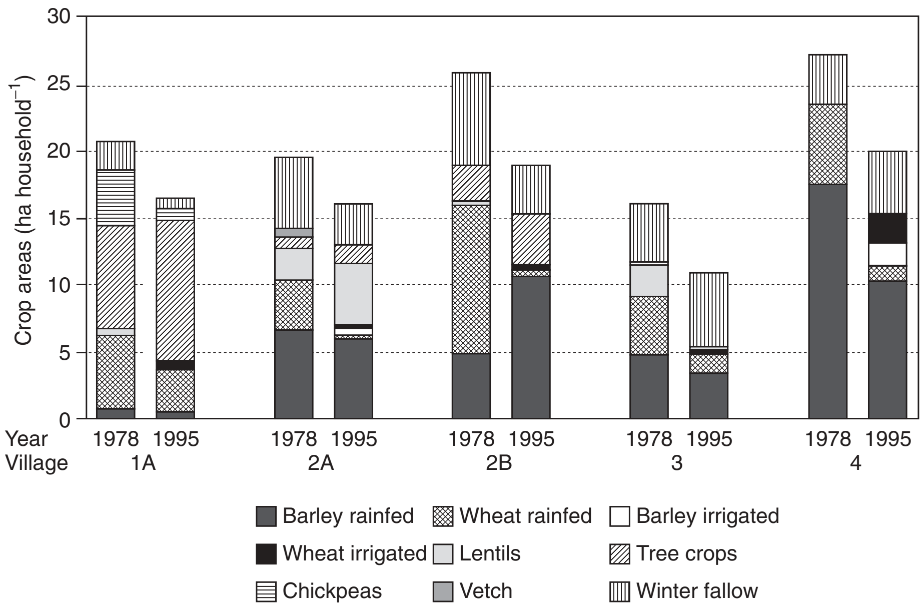


Figure 1. Areas of the different rainfed and irrigated crops, tree crops and winter fallow in the five villages averaged for 1977–79 and 1994–96. (Detailed survey).

but the area per household was the highest in Village 1A where it had increased to nearly 10 ha by 1996 (Figure 1). The modest area of tree crops in Villages 2A and 2B also increased over time. Between 20 % and 47 % of the area of each household's arable land was sown to rainfed wheat in 1977–79, but, with the exception of Village 1A, the percentage decreased over time. Indeed, in Villages 2A, 2B and 4 very little rainfed wheat was being grown in 1993–95. With the exception of Village 1A where only a small area was grown, rainfed barley was a significant crop in the other villages, with 21 % to 64 % of the arable land planted to this crop. In 1977–79 chickpeas were being grown only in Village 1A and by 1993–95 the area per household was only 0.8 ha. Similarly, originally lentils were being grown in all villages except for Village 4 in the driest zone. By 1993–95, however, households in the sample had completely stopped growing lentils in Villages 1A and 2B. In contrast the area had doubled in Village 2A. Vetch, which formerly had been grown in Villages 2A, 2B and 3, was not being grown at all in 1993–95. Modest areas of irrigated wheat were being grown in all villages by 1993–95, and the largest area was being grown by the sample households in Village 4. Similarly, by 1993–95 the households in the sample in Village 2A were each growing 0.5 ha irrigated barley and in Village 4 they were each growing about 1.8 ha. The area of winter fallow decreased over the 19 years in Villages 1A, 2A and 2B, but increased substantially in Villages 3 and 4 (Figure 1).

The changes in cropping patterns were also accompanied by changes in grain yields of rainfed barley and wheat (Figure 2). In Villages 1A, 2A and 2B where the rainfall is more abundant, cereal yields were substantially higher than in the two villages in

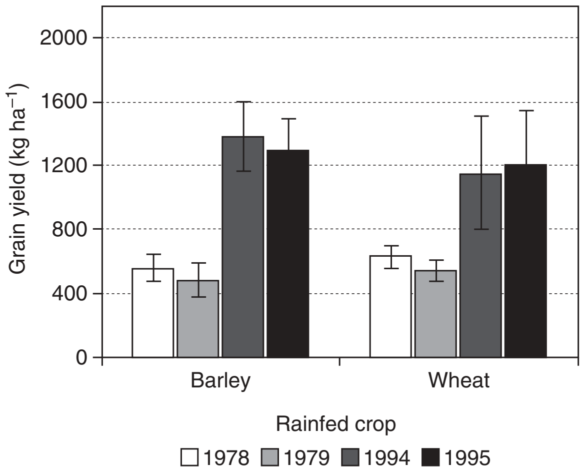


Figure 2. Grain yields of rainfed barley and wheat averaged across the farms at the harvests in four years. (Error bars show standard errors.)

Table 5. Least square means of ewe inventory, the lambing rate, milk offtake from ewes, and ewe and lamb mortality for the same sample of flocks across the four years. (Detailed surveys).

| | n used in GLM analysis | Year of observation | | | | |
|---|---|---|---|---|---|---|
| | | 77/78 | 78/79 | 94/95 | 95/96 | *s.d.* |
| Ewe inventory | 22 | 14.1[a†] | 17.1[a] | 24.8[b] | 23.8[b] | 7.87 |
| Lambing rate‡ (%) | 20 | 90.2[ab] | 78.4[b] | 98.6[a] | 104.2[a] | 18.35 |
| Milk offtake§ (kg ewe$^{-1}$) | 20 | 76.7[a] | 58.4[b] | –¶ | 75.0[a] | 20.67 |
| Ewe mortality (%) | 22 | 6.5[a] | 1.6[bc] | 3.5[ab] | 1.5[c] | 5.01 |
| Lamb mortality (%) | 20 | 4.3 | 7.2 | 3.1 | 2.9 | 7.50 |

†Means in rows followed by different superscripts are significantly different at $p < 0.05$.
‡Number of lambs born per ewe exposed to rams, expressed as a percentage.
§Ewes are milked after lambs have been weaned at two-to-three months of age.
¶Households were not asked to recall milk offtake of ewes from the previous lactation.

the drier zones. Moreover, in the former three villages the improvement in yields of both wheat and barley crops were more consistent across farms. Mean grain yields of irrigated barley at the 1995 harvest (mean = 3351 kg ha$^{-1}$, *s.d.* = 402.1, n = 6) and wheat (mean = 3925, *s.d.* = 1988.2, n = 8) were nearly three times higher than the yields of the respective rainfed crops.

The increase in the sheep inventory over time seen in the general survey (Table 3) was reflected in the increase in the ewe inventory in the detailed survey (Table 5). Ewes accounted for 88 % and 85 %, respectively, of the total sheep in 1977–79 and 1994–96. Ewe fertility, expressed as lambing rate, varied between years, with a lower rate in 1978/79 as compared with the two more recent seasons (Table 5). This pattern of fertility was seen across all the villages except Village 4. Mean milk offtake per ewe was also affected by year but not by village, with lower yields following the winter of low rainfall, 1978/79, whereas the other two years were similar. Mortality of ewes

Table 6. Least square means of the annual amounts of hand-fed feeds offered during winter (kg air-dried feed per ewe equivalent of 45 kg†). (Data from 22 households were used in the GLM analysis).

| | Winter of observation‡ | | | |
|---|---|---|---|---|
| | 77/78 | 78/79 | 95/96 | *s.d.* |
| Cereal straw§ | 220 | 154 | 171 | 114.8 |
| Barley and wheat grain¶ | $164^{a}$†† | $119^{b}$ | $151^{ab}$ | 64.0 |
| Agro-industrial by-products | 47 | 38 | 77 | 48.2 |
| Total hand-fed feeds | 433 | 315 | 413 | 151.9 |
| Total MJ in hand-fed feeds | 3711 | 2660 | 4049 | 1938.6 |

†Ewe equivalents were derived from the number of sheep and goats by age and gender category.
‡Farmers were not asked to recall the amounts of feed offered during the winter 1994/95.
§Usually includes some lentil straw.
¶97 % of this grain is barley.
††Means in rows followed by different subscripts are significantly different at $p < 0.05$.

differed between years but mortality of lambs was similar across years. The somewhat higher mean lamb mortality in 1978/79 was due to the 12.8 % mortality in Village 2B that winter.

Some major changes to the feeding calendar had occurred by 1996. In Villages 2A, 2B and 3 the duration of the period of hand-feeding of cereal grains and agro-industrial by-products in winter increased by one month (i.e. until the end of March). This implies a decrease in the dependency on communal village grazing areas but not necessarily a reduced grazing pressure. As a consequence, by 1994–96 the winter feeding period lasted seven months in Villages 2A and 2B, and six months in Village 3. In contrast, the duration of the winter feeding period decreased in Village 1A (three-to-four months), because in autumn the larger flocks were being moved to neighbouring villages with channel irrigation to graze sugar-beet residues and cotton residues. A shorter duration of winter hand-feeding was noted also in Village 4 since rainfed and irrigated barley were being grazed at the green stage in March and stubble grazing continued for a month longer in autumn.

Year-to-year variations were seen in the annual amounts of the various hand-fed feeds offered. Only in the case of barley and wheat grain did they reach statistical significance (Table 6). The winter of lower-than-average rainfall, 1978/79, had the most pronounced effect on the total amount offered, with a 120 kg decrease compared with 1977/78. The amounts offered were similar for 1977/78 and 1995/96, two years with fairly similar rainfall. However, the quantity of agro-industrial by-products – wheat bran, cottonseed cake, cottonseed hulls, ready mixed concentrates and bread – tended to increase in the winter 1995/96. Because of large between-flock variations, the total ME from the hand-fed feeds offered in the three years was similar.

## DISCUSSION

The second phase of the study collected information concerning changes to the land and water use, the crop productivity and the small ruminant component of the

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mixed farming systems over the previous 19 years, as well as to the levels of off-farm employment. This provided the basis to examine whether the apparent intensification of crop production was accompanied by changes to the small ruminant component of the farming systems. By retaining the original sample from 1977, the confounding effect on the changes of using a different sample was largely removed. The confounding effect of farmer age on the changes is acknowledged, however, and taken into consideration when interpreting the results. As the original general sample included a high proportion of all the farming households in the villages and nearly half of the original sample could still be traced 19 years later, the general sample of the second phase still represented a satisfactory proportion of the households in the villages. In contrast, the number of households in the detailed sample of the second phase was small and, therefore, was less representative of the farming households in the villages. To overcome this weakness, the follow-up visits in 2000 to the villages in the sample, and to others nearby, served to verify the findings from the villages in the sample. In addition, the findings from other recent surveys in Syria were studied and discussed with the respective authors.

*Changes in land and water use and small-ruminant ownership*

The expansion of irrigated crop production, especially in Villages 2B and 4, is similar to the recent observations of Pape-Christiansen (2000) in Zone 2 and Nielsen and Zöbisch (2001) in Zone 4, and reflects the increase of irrigated crop production across the country. A trend towards specialization in tree crops – mainly olives – was found in Villages 1A, 2A and 2B. In Village 1A there were no irrigation channels in 1977 and most of the households already owned tree crops that covered 40 % of the farmed area. By 1996 trees covered two-thirds of the area. The proportion of households owning tree crops increased in Villages 2A and 2B, in the latter mainly because of a district-wide olive development project on the areas with shallow soils. This reduced the area of communal grazing and may partly explain the decrease in the sheep inventory in Village 2B. Pape-Christiansen (2000) reported a similar association on farms sampled in El Bab district to the east of Village 2B, when comparing the situation in 1994 with 1984. Selling sheep to repay loans was another reason why inventories decreased on farms in that district.

The decrease in the number of families growing leguminous crops in Villages 1A and 2B and the unpopularity of vetch accompanied a trend towards cereal monoculture using intensive methods. There has been a reduction also in the area of winter fallow, and much of the area is used to grow summer crops later in the season. This trend and specialization in crop-only enterprises in Village 1A, and to a lesser extent in Villages 3 and 4, is contrary to the goals of many regional and national research programmes during the same period. Some of these programmes tested annual medics and annual forage legumes to improve feed supplies and promote crop/livestock integration, and thereby sheep productivity (Cocks and Thomson, 1988; Cocks, 1993). Conceptually, these integrated systems have many advantages, but achieving widespread adoption of the new technologies has proved illusive (Christiansen *et al.*, 2000a, 2000b).

A major disadvantage of legume crops is the high labour requirement for hand-weeding and hand-harvesting, the latter usually requiring paid labour. Indeed, a rapid rise in the cost of hand-harvesting discouraged households from cultivating lentils (ICARDA, 1997). There are other problems that contribute to farmers' lack of interest in vetch – low yields, technical and cost considerations associated with mechanization, and poor availability of seed – and these have not yet been fully resolved (Christiansen *et al*., 2000b). Solutions need to be found though, since cereal monoculture increases the risks of pests (Bahhady *et al*., 1997; Al-Chaabi, 1997; Christiansen *et al*., 2000b), reduces yields in wheat, and yield reductions in barley are anticipated (Jones and Singh, 1995).

Whereas the majority of the households in Village 1A had specialized in annual and tree crops by 1996, the number of households owning only sheep or mixed flocks had decreased markedly. The few that still owned sheep had substantially increased their flock inventory. Thus, in 1996 goat-keeping alone was more common than keeping sheep or mixed flocks and the goat inventory had increased by 50 %. A feud in Village 1A in the late 1970s contributed to these changes. As a result, six of the twelve households that had left the village but continued to cultivate their land had stopped owning sheep. The follow-up visit in 2000 to a village close to Village 1A confirmed these general trends, with olives covering 90 % of the area, goats being more important than sheep and large sheep flocks from another village coming to graze the stubble. In contrast, in villages close by with access to water channels, a wide diversity of irrigated crops was found and sheep ownership was more common.

*Intensification of crop production*

Even though the crop yields are based on farmers' estimates for only two consecutive years in each phase of the study, there is evidence in the villages in the higher rainfall zones of substantial increases in the cereal grain yields over the19 years. This indicates the successful intensification of crop production. Although the reasons for the higher crop yields were not studied in detail during the second survey, they include higher input of fertilizers, the sowing of better varieties and supplementary irrigation of wheat (Abdelali-Martini, 2000; Pape-Christiansen, 2000). Increased ownership of tractors in villages with higher rainfall facilitated these changes. The cereal yields in the two driest villages were highly variable and crop failures were more frequent. Mazid *et al*. (1994), who studied the barley/livestock systems over a wide area of Syria, reported that cereal yields in the driest areas had changed little with time.

The households in the drier areas benefited less from intensification since yields were lower in any case and the increases over the 19-year interval between the surveys were smaller and sometimes absent. Without resorting to irrigation, the families in the two driest villages remained at a disadvantage. In Village 3 in 1996, only one of the 18 wells in use had sufficient flow for irrigation purposes, the others being used to supply drinking water. By 1996, a third of the households in Village 4 had invested in wells so that they could grow irrigated crops. This enabled them to halve the area of rainfed barley and replace much of it with irrigated wheat and barley. This practice was clearly non-sustainable since by mid-2000, following two winters with well-below-average rainfall, the farmers had abandoned irrigation after just four or five seasons because the water from the wells was too saline (Hoogeveen and Zöbisch, 1999).

There is contradictory evidence in the villages as to the compatibility of crop intensification and small ruminant production on the same farm. The intensification of crop production in the two villages sampled in Zone 2 did not take place at the expense of sheep ownership. In contrast, households in the villages in the driest zones, where crop intensification was not feasible, were more likely to specialize. Due to the problems facing the introduction of annual leguminous pastures and forage crops mentioned above, the prospects for closer crop/livestock integration at the farm-level promoted by many scientists, appear to be poor. Such integration continues, however, according to the alternative definition, in which small ruminants remain an integral part of the wider cropping and pastoral systems through the spatial and temporal movement of the owners with their animals between farms, districts and regions.

*Off-farm employment*

In villages sampled in 1996, at least 59 % of the families had members other than the farmer himself working off-farm. Often the young men worked in Lebanon or Jordan and the women worked mainly in teams contracted to weed and harvest crops. These findings agree with those of Abdelali-Martini (2000) in a survey of off-farm activities in Zones 1, 2 and 3 in Aleppo and Idleb Provinces. The author found that 73 % of the 120 households in the sample had a member working off-farm, and in 60 % of the households at least one member worked in the non-agricultural sector.

Of the five villages, the households sampled in Villages 3 and 4 had the highest proportion of their members working off-farm. In the driest years, whole families moved with or without their animals to be closer to sources of employment and many only returned to their village at sowing and harvesting time. These two villages were nearly uninhabited at the time of the follow-up visit in mid-2000, which was a particularly dry year. Twenty years earlier Thomson *et al*. (1989) made the same finding in another village in Zone 4, 30 km to the east. The increase in the area of winter fallow in these villages is also evidence that labour is being diverted to off-farm employment where earnings are higher (Figure 1). These observations suggest that even more villages situated in the belt between the low-potential agricultural zones and the steppe will be abandoned for at least part of the year unless they lie in areas with channel water for irrigation (Nielsen and Zöbisch, 2001).

*Evidence of better small-ruminant productivity*

The satisfactory ewe fertility in 1994/95 and 1995/96 in these small flocks was the only evidence of better sheep productivity, and the levels agree with the fertility levels observed in Syria over the last 20 years (Thomson *et al*., 2003). They are also similar to that found in flocks kept under optimal management (Thomson and Bahhady, 1995). However, the amounts of winter feed offered appear to be excessive (Table 6), in 1995/96 being close to 4020 MJ ME, the estimated annual ME needs of a 45 kg ewe bearing a single lamb and yielding 110 kg of milk (Thomson, 1987; after correcting the live weight to 45 kg). Single interviews are unsatisfactory for collecting such information but similar amounts were reported for 1977/78 when monthly visits were made. Other recent studies in the area also using repeated visits reported somewhat lower amounts (Thomson *et al*., 1989; Opitz *et al*., 1996; Thomson *et al*., 2000). Wachholtz (1996) quotes earlier work by Nygaard *et al*. (1982) who found that the proportion of hand-fed feedstuffs in the annual diet was far higher in Aleppo Province than in the other provinces of Syria due to more intensive commercial livestock production, easier access to feedstuff markets and higher stocking rates on the steppe. If these levels of winter feeding could be sustained in all villages, they would meet the ME needs of Awassi ewes producing an additional 40 kg milk. The liberal levels of feeding help explain the low levels of mortality, which are similar to the accurately determined values reported for similar zones (Opitz *et al*., 1996; Thomson *et al*., 2000).

*Future prospects*

Gradually improving agronomic practices and increased use of higher-yielding varieties are likely to continue in villages where there is sufficient rainfall and soils are deep. These will increase crop yields still more. Although previous attempts have resulted in little or no sustained adoption, in all but the driest villages renewed efforts should be made to introduce or re-introduce food and forage legumes to reduce the proportion of the arable land sown to cereals.

Although there are concerns about the sustainability of irrigated crop production, at least when it depends on ground-water supplies, farmers are likely to continue to find it attractive, given the four times greater and more stable income than from rainfed crop production (Pape-Christiansen, 2000). Once water tables have decreased to the point where irrigation is no longer feasible, however, tree crops might be the only alternative to cereals even though it takes 7 – 10 years before they generate an income. The future of the plantations in the hilly areas of Zone 1 will depend on introducing alternative weed-control practices which prevent the soil erosion that is presently caused by the practice of cultivating with the slope (Zöbisch *et al*., 1997).

Off-farm employment will continue to play a key role in supplementing the income of the poorest families, not only for the vulnerable families in the dry zones but also for families with smaller rainfed farms in Zone 2 (Pape-Christiansen, 2000).

The complex changes to small ruminant ownership resulting from the intensification process indicate that for each zone specific options for livestock development need to be considered. In cases where sheep ownership has fallen considerably, such as in Village 1A, dairy-type goats have a niche on farms where crops and tree crops predominate. The presence of goats in all the villages suggests that research is needed to define optimal milk yields of dairy goats using the available feed resources.

Provided the current liberal levels of winter feeding can be maintained, introducing genotypes of ewes with a higher milk yield potential would enhance the incomes for families specializing in milk production, particularly as there is a strong demand for milk products due to the proximity of Aleppo. Farmers in Village 2B reported that a

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proportion of their ewes lambed twice in one year. These farmers were keen to receive rams selected for the improved milk yield of their progeny.

Ownership of dairy cows was surprisingly low in the sample despite the government's programme to promote the dairy sector. Results from another survey confirms this finding, with only 41 cows being owned by a sample of 117 households among 46 villages in Zones 1, 2 and 3 (Abdelali-Martini, 2000). However, dairy cows are an option for households with smallholdings, some land which can be irrigated, and a shortage of labour for herding. Moreover, dairy cows provide an opportunity to reintroduce forages into crop rotations. Before the introduction of tractors, farmers were accustomed to growing alfalfa, chickling and vetch for their work oxen. There is a need to assess how the forages required for dairy-cow feed can best be integrated into the current cropping systems in Zone 2. Also, dairy cows, sheep and goats need to be compared as suppliers of milk and milk products.

The trend towards specialization in either barley production for sale or in commercial livestock raising in the drier areas was discussed by Tutwiler *et al*. (1997). Nielsen and Zoebisch (2001) report on a village close to Village 4 where 32 % of the households owned no livestock, but other households in the same area were tending to specialize in commercial livestock production such as lamb fattening. Studies are needed to define the circumstances in which commercial systems are economically viable and to assess their environmental impact.

The results from the surveys suggest that the mixed farming systems in the five villages studied and probably in Aleppo Province as a whole, are still passing through a period of transition. The cropping component will undoubtedly continue to change, driven by several factors including government policy, adequate availability of inputs and the proximity of a large urban market. The small ruminant component is less likely to change significantly in the near future unless the sector is given higher priority in national policy. Finally, as the attempts to introduce leguminous pasture and legume crops have shown, the prospects for better crop/livestock integration at the farm-level are limited. Indeed, the results from this study of the mixed farming systems in Aleppo Province suggest that a proportion of the farming households in the villages are tending to specialize in crops whereas others are specialising in small ruminant production. This trend is likely to continue in the future.

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