Breeding programmes

1 Introduction

This section draws on the information provided in the country reports to present an analysis of the state of implementation of livestock breeding programmes and of capacity to implement them (see the introduction to Part 3 for an overview of the country coverage and the use of the national breed population as a unit of analysis). The state of the art in breeding programmes is described separately in Part 4 Section C. Breeding programmes were defined in the country-report questionnaire as follows:

"systematic and structured programmes for changing the genetic composition of a population towards a defined breeding goal (objective) to realize genetic gain (response to selection), based on objective performance criteria.
Breeding programmes typically contain the following elements:
• definition of breeding goal;
• identification of animals;
• performance testing;
• estimation of breeding values;
• selection;
• mating; and
• transfer of genetic gain.
Breeding programmes are usually operated either by a group of livestock breeders organized in a breeders' association, community-based entity or other collective body; by a large commercial breeding company; or by the government."

In addition to reporting on programmes of this type, countries also provided information on other activities and strategies aimed at improving the quality of their livestock populations in genetic terms, i.e. measures taken to promote cross-breeding or the wider use of breeds perceived to be more productive.

This section provides an update of the material on the state of capacity in genetic improvement programmes presented in the first report on *The State of the World's Animal Genetic Resources for Food and Agriculture* (first SoW-AnGR) (FAO, 2007a).[1] The country-report questionnaire addressed the main themes covered in the first SoW-AnGR. However, because of the different reporting methods, most of the findings presented below are not directly comparable to those presented in the earlier publication.

2 Global overview

For each of the so-called "big five" species (cattle, sheep, goats, pigs and chickens), the majority of country reports indicate the presence of breeding programmes (Table 3C1). The figures are higher for cattle (around 90 percent each for the dairy, beef and multipurpose categories) than for the other species (around 80 percent in all cases). While the figures appear to show that breeding programmes are widespread, in some cases the activities referred to in the country reports do not seem to be breeding programmes in the strict sense of the term (see introduction). Many countries report the presence of breeding programmes, but also that some of the key elements of breeding programmes are not in place for any of their breeds. For this reason, the figures presented in the table need to be treated with some caution. It should also be noted that the figures merely

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[1] FAO, 2007, Part 3 Section B (pages 215–241).

indicate the presence of at least one programme targeting the respective species. The numbers of breeds covered may be high or low, as may the effectiveness and reach of the programmes.

The regional breakdown presented in Table 3C1 shows that programmes for beef and dairy cattle are widespread in almost all regions and subregions (dairy cattle programmes in North and West Africa are the main exception). Gaps are more widespread in the case of multipurpose cattle (e.g. in South Asia, the Near and Middle East and Central America) and even more so in other

species (e.g. sheep, pigs and chickens across most subregions of Africa; and sheep and goats in East Asia and the Southwest Pacific).

In the case of species other than the big five, the proportion of countries indicating that they have breeding programmes in place is generally low (Table 3C2). Only in the case of horses (74 percent), buffaloes (58 percent) and Bactrian camels (80 percent), do the majority of countries reporting the presence of the respective species indicate that they have breeding programmes in place.

TABLE 3C1

Proportion of countries reporting the existence of breeding programmes – regional breakdown

Regions and subregions	Number of countries	Dairy cattle	Beef cattle	Multipurpose cattle	Sheep	Goats	Pigs	Chickens
		%						
Africa	**40**	76	90	82	58	75	57	56
East Africa	8	88	100	86	50	88	50	63
North and West Africa	20	57	83	83	60	60	56	42
Southern Africa	12	92	91	78	58	92	64	75
Asia	**20**	95	89	80	74	80	75	85
Central Asia	4	100	100	100	100	100	50	100
East Asia	4	100	75	100	50	50	75	75
South Asia	6	100	100	60	80	83	100	83
Southeast Asia	6	83	83	75	67	83	67	83
Southwest Pacific	**7**	100	100	100	67	40	86	86
Europe and the Caucasus	**35**	97	88	97	97	94	97	94
Latin America and the Caribbean	**18**	100	100	80	94	89	100	83
Caribbean	5	100	100	75	100	100	100	60
Central America	5	100	100	60	100	100	100	80
South America	8	100	100	100	88	75	100	100
North America	**1**	100	100	100	100	100	100	100
Near and Middle East	**7**	83	100	67	86	71	0	86
World	**128**	91	93	87	79	81	80	79

Note: The figures and bars represent the number of countries indicating the presence of breeding programmes (at least one) as a proportion of the number of countries reporting the presence of the respective species.
Source: Country reports, 2014.

TABLE 3C2

Proportion of countries reporting the existence of breeding programmes – species breakdown

Species	Number of countries reporting presence	Percentage of countries with breeding programmes (at least one)
Dairy cattle	116	91
Beef cattle	103	93
Multipurpose cattle	103	87
Sheep	123	79
Goats	126	81
Pigs	112	80
Chickens	126	79
Horses	62	74
Ducks	43	40
Rabbits	43	44
Buffaloes	31	58
Turkeys	31	45
Asses	30	0
Geese	28	43
Guinea fowl	20	30
Dromedaries	14	29
Quails	14	36
Ostriches	13	31
Pigeons	11	9
Deer	8	0
Alpacas	7	0
Llamas	6	33
Muscovy ducks	6	33
Bactrian camels	5	80
Yaks	5	40
Guinea pigs	4	0

Source: Country reports, 2014.

3 Stakeholder involvement

The systematic implementation of breeding programmes requires stable organizational structures. Programmes can be organized by public-sector bodies, by the private sector, by non-governmental organizations (NGOs) or via collaborative efforts involving more than one sector. Table 3C3 summarizes the information provided in the country reports regarding the sectors and groups of stakeholders that operate breeding programmes (i.e. take the leading or organizational role in the operation of such programmes). For the purposes of this analysis, the private and non-governmental sectors are divided into the following categories:

- national commercial companies (companies based in the respective reporting country);
- external commercial companies (companies based outside the reporting country);

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TABLE 3C3
Extent of involvement of different stakeholder groups as operators of breeding programmes

Regions and subregions	Number of countries	Government	Livestock keepers organized at community level	Breeders' associations or cooperatives	National commercial companies	External commercial companies	NGOs	Others
					%			
Africa	**40**	**52**	**29**	**32**	**17**	**6**	**15**	**9**
East Africa	8	58	24	26	15	4	13	7
North and West Africa	20	49	28	37	11	9	19	8
Southern Africa	12	54	33	29	28	4	11	10
Asia	**20**	**83**	**38**	**43**	**30**	**22**	**28**	**11**
Central Asia	4	94	60	40	40	37	40	0
East Asia	4	75	29	43	36	39	29	0
South Asia	6	83	45	26	16	0	37	6
Southeast Asia	6	77	23	57	32	20	13	30
Southwest Pacific	**7**	**47**	**40**	**45**	**45**	**60**	**43**	**6**
Europe and the Caucasus	**35**	**37**	**9**	**76**	**25**	**20**	**17**	**14**
Latin America and the Caribbean	**18**	**60**	**33**	**57**	**55**	**26**	**29**	**25**
Caribbean	5	70	29	15	24	13	3	3
Central America	5	60	29	74	80	17	54	20
South America	8	54	38	72	59	40	29	41
North America	**1**	**0**	**71**	**100**	**86**	**57**	**0**	**100**
Near and Middle East	**7**	**78**	**43**	**20**	**24**	**20**	**24**	**18**
World	**128**	**54**	**27**	**51**	**29**	**19**	**21**	**14**

Note: The figures refer to the percentage of countries (among those reporting the respective species) in which the respective stakeholder group operates breeding programmes averaged over seven species/categories, i.e. the "big five" species (cattle, sheep, goats, pigs and chickens), with the three categories of cattle breeds (dairy, beef and multipurpose) treated separately.
Source: Country reports, 2014.

- breeders' associations or cooperatives (membership organizations in which individual livestock breeders join together to pursue common goals);
- NGOs (NGOs that are not breeders' associations: e.g. those involved in promoting rural development); and
- livestock keepers organized at community level (community-level structures, whether traditional or newly established, that enable livestock keepers to act collectively to organize genetic improvement activities).

At global level, the most frequently reported operators of breeding programmes are governments and breeders' associations. However, there are major differences between regions in terms of the reported significance of these two categories. Breeders' associations are frequently reported

in Europe and the Caucasus and North America, but much less so in most developing regions. Latin America and the Caribbean (or more specifically the Central and South America subregions) is a partial exception to this pattern. Conversely, government-operated programmes are reported more frequently in all developing regions (most particularly in Asia and the Near and Middle East) than in Europe and the Caucasus and North America. No government-operated programmes are reported in the latter region. Programmes operated by national and external commercial companies are reported from all regions of the world (most frequently the Southwest Pacific, North America, and Central and South America). The species involved are most commonly chickens, pigs or dairy cattle (see supplementary tables A3C1, A3C6 and A3C7).[2] Programmes operated by livestock keepers organized at community level are quite widely reported across all developing regions. However, the country reports generally provide little information about the nature of these programmes. Programmes operated by NGOs are reported in most regions, but with relatively low frequency in most cases (highest levels in Central America, the Southwest Pacific and Central Asia).

Whatever sector takes the leading role in organizing a breeding programme, a range of different tasks need to be addressed. A variety of different stakeholders may be involved in each of these tasks, either in terms of planning (e.g. identifying breeding goals and planning how the programme will be organized) or in terms of practical implementation (e.g. recording animals' performance, undertaking genetic evaluations or delivering artificial insemination services). These activities can be thought of as the "building blocks" of breeding programmes. Some of these building blocks can serve a number of different purposes, i.e. they can contribute not only to breeding programmes, but also to other aspects of livestock development. For example, animal identification can facilitate disease control, prevention of livestock theft and the delivery of support payments (FAO, 2015). Performance

recording can play a role in herd management. Thus, the building blocks may be in place even if no breeding programmes are yet in operation.

Countries were asked both to provide information on the level of implementation of the various building blocks of breeding programmes and to report on the level of involvement of different stakeholders in their implementation. Because some of these activities can be undertaken by individual livestock keepers, and because of the prominent role of research organizations in undertaking some of them, these two stakeholder categories were included in the list of options provided in the country-report questionnaire. Countries were asked to provide scores for the level of involvement of the various categories. The responses (with respect to the big five species) are summarized in Figure 3C1.

Governments, research organizations, breeders' associations and individual livestock breeders/keepers are reported to play relatively prominent roles across all activities, both in ruminants and monogastrics. In the case of commercial companies, involvement in most activities is markedly higher in monogastrics and dairy cattle than in other types of livestock. The role of NGOs is reported to be limited across all categories of activity. The global figures conceal some regional differences. As in the case of the figures presented in Table 3C3, the roles of breeders' associations are generally more prominent than those of governments in developed regions, while the opposite is the case in developing regions.

Figure 3C2 shows the distribution of countries where breeders' associations are reported either to operate breeding programmes or to have some involvement in implementing the elements of breeding programmes. As noted above, the term "breeding programme" appears not to have been interpreted uniformly across all the country reports and the same may be true of the phrase "operating a breeding programme". It is therefore possible that the number of countries shown to have programmes operated by breeders' associations (i.e. as green rather than yellow on the map) may be an overestimate.

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[2] Supplementary tables for Part 3 are provided on CD ROM and at http://www.fao.org/3/a-i4787e/i4787e197.pdf

FIGURE 3C1

Stakeholder involvement in breeding-related activities in ruminants and monogastrics – global averages

Score for ruminant species (cattle, goats and sheep)

Score for monogastric species (pigs and chickens)

Legend:
- Governments
- Research organizations
- Breeders' associations or cooperatives
- Individual breeders/livestock keepers
- National commercial companies
- External commercial companies
- Non-governmental organizations
- Others
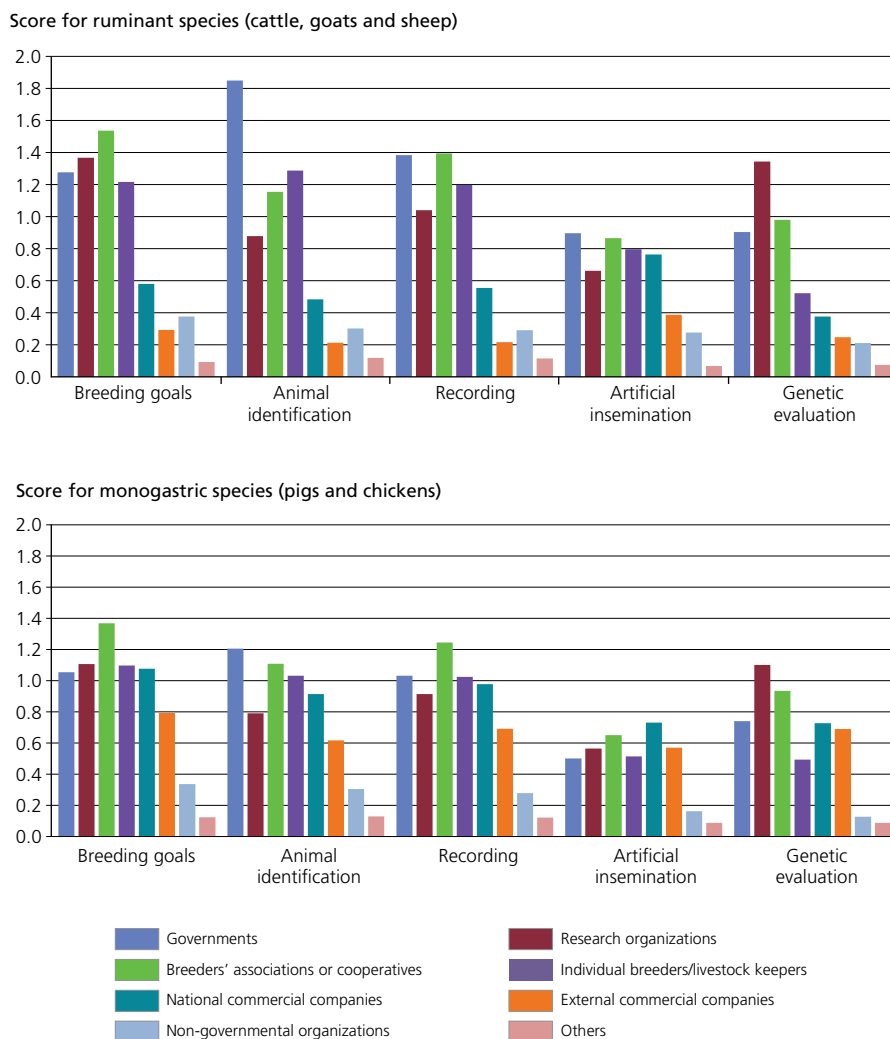
Note: Countries provided scores (at species level) for the level of stakeholder involvement in each activity. Answering the question was optional (the number of responses varied from species to species). The scores were converted into numerical values (none = 0; low = 1; medium = 2; high = 3). The figures shown are global averages for the respective groups of species.
Source: Country reports, 2014.

FIGURE 3C2

Involvement of breeders' associations in breeding programmes and elements of breeding programmes

- Countries reporting that breeders' associations operate breeding programmes for at least one species
- Countries reporting that breeders' associations are involved in some element of breeding programmes for at least one species
- Countries reporting no involvement of breeders' associations in breeding programmes
- Countries that did not report
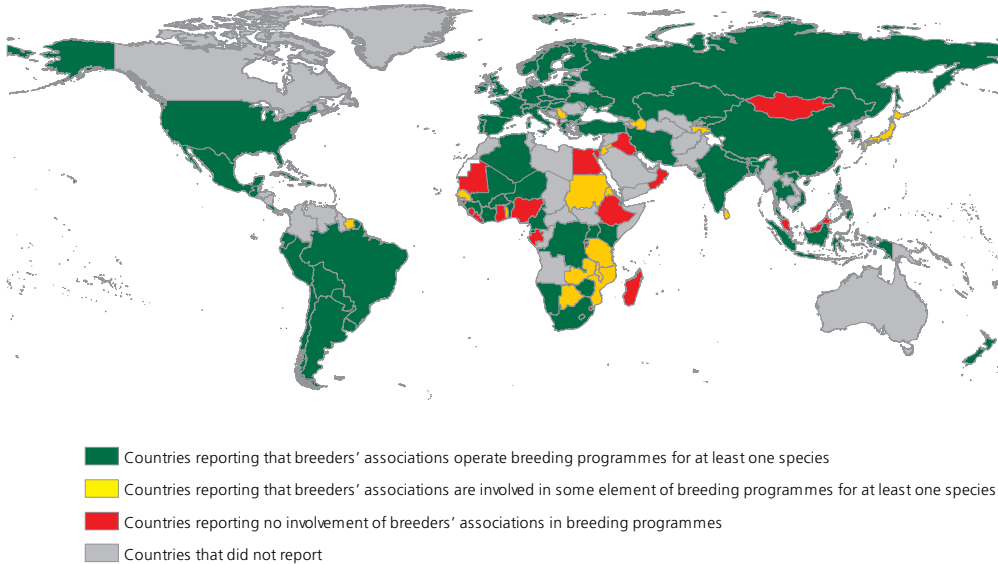
Source: Country reports, 2014.

4 Educational, research and organizational capacities

The successful development and operation of breeding programmes requires a high level of technical capacity and knowledge on the part of the stakeholders involved. Many country reports mention limited knowledge on the part of livestock keepers and technicians as a significant constraint to the implementation of breeding programmes. Analysis of country-report responses on the general state of education and training in the field of animal genetic resources (AnGR) is presented in Part 3 Section A. However, countries were also asked specifically to provide scores (none, low, medium or high) for the state of education and training in the field of animal breeding. The responses are summarized in Figure 3C3. The global cumulative score of 12 out of a potential maximum of 21 illustrates that there is a major deficit in the provision of education and training in this field.

Africa and the Near and Middle East are the regions reporting the lowest levels of provision. Responses related to the state of implementation the Global Plan of Action for Animal Genetic Resources reveal a similar picture (Figure 3C4). Approximately 31 percent of reporting countries consider that their provision of training and technical-support programmes for the breeding activities of livestock-keeping communities is at an adequate level; 43 percent report that they have some programmes of this type in place, but that they require improvement; 26 percent report that they have no such programmes. Moreover, 39 percent report that they have made no progress in terms of improving provisions since the Global Plan of Action was adopted in 2007.

Countries were also asked to report on the state of their research activities in the field of animal breeding, again by providing a score. The responses are summarized in Figure 3C5. On a global scale, as in the case of training,

FIGURE 3C3
State of training in the field of animal breeding
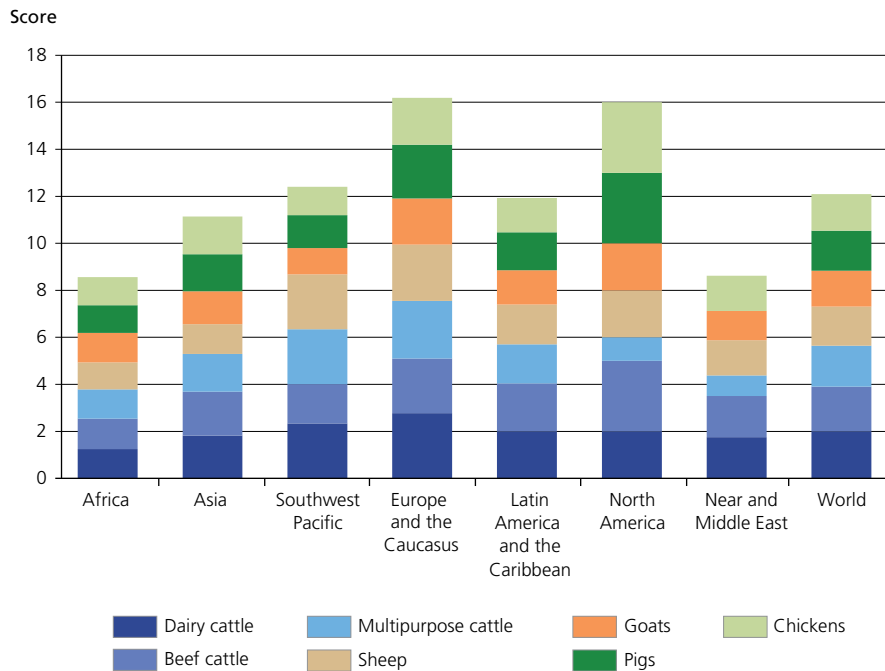
Score

Note: Each country provided a score for the level of provision with respect to each species. The scores were converted into numerical values (none = 0; low = 1; medium = 2; high = 3) and an average score calculated for the respective species × region combinations (countries where the respective species was not reported to be present were excluded from the calculations). The length of each bar corresponds to the cumulative average scores across all species for the respective region. The maximum potential score is 21 (3×7).
*Source:* Country reports, 2014.

there is a major gap between the current level of research activity and the potential maximum (high level of research in all countries for all species). In practice, the effect of this shortfall is likely to be reduced by the diffusion of research results from one country to another. However, the concentration of research in certain regions or countries may increase the likelihood that some production systems and species are inadequately covered. Moreover, there may be constraints to the diffusion of knowledge, particularly into less-developed countries. Scores for the state of research are highest in North America and Europe and the Caucasus, and lowest in Africa.

As noted above, breeding programmes are complex undertakings that involve a range of different tasks. Establishing a successful breeding programme requires not only the technical capacity to undertake these tasks, but also organizational structures that enable these tasks to be carried out systematically and on a sufficiently large scale. This is likely to require substantial and well-organized involvement of the livestock keepers that raise the respective breeds. Countries were asked to report (again by providing a score) on the level of livestock-keeper organization with respect to animal breeding (taking all the various elements of breeding programmes into account). The responses are summarized in Table 3C4. Scores

FIGURE 3C4

State of implementation of training and technical support programmes for the breeding activities of livestock-keeping communities
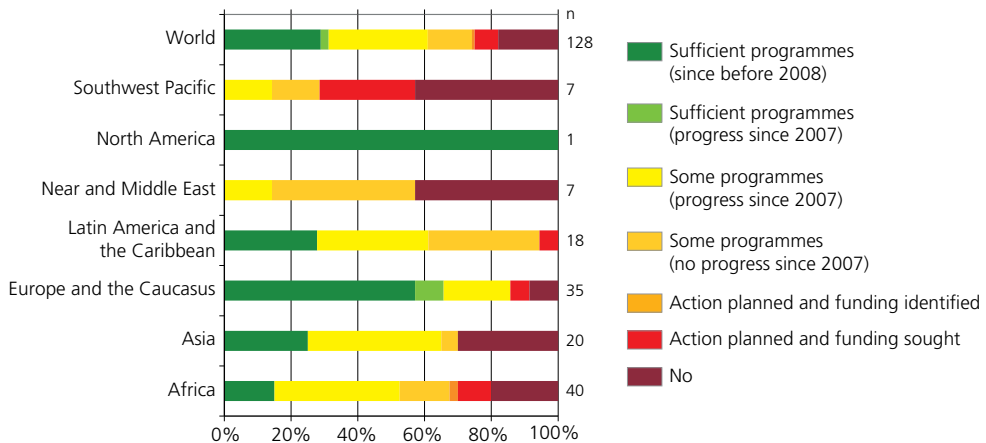
Note: Countries were asked the following question: Have training and technical support programmes for the breeding activities of livestock-keepers been established or strengthened in your country? Response options were as follows: a. Yes, sufficient programmes have existed since before the adoption of the GPA; b. Yes, sufficient programmes exist because of progress made since the adoption of the GPA; c. Yes, some programmes exist (progress has been made since the adoption of the GPA); d. Yes, some programmes exist (but no progress has been made since the adoption of the GPA); e. No, but action is planned and funding identified; f. No, but action is planned and funding is sought; g. No. GPA = Global Plan of Action for Animal Genetic Resources; n = number of responding countries. Source: Country reports, 2014.

for the level of organization are highest in Europe and the Caucasus, Latin America and the Caribbean and North America and lowest in Africa, the Southwest Pacific and the Near and Middle East.

5 Breeding methods and activities

An overview of the status of breeding programmes is presented above (Subsection 2). This subsection presents an analysis of the level of implementation of the various elements of breeding programmes and of the types of programmes that are in operation, specifically the prevalence of programmes that involve cross-breeding.

Countries were asked to indicate the number of exotic and locally adapted breed populations for which breeding goals have been defined and in which the following activities are being implemented:

- animal identification;
- recording of pedigrees;
- recording of animal performance;
- use of artificial insemination (AI);
- implementation of genetic evaluation following the classic approach (i.e. not including the use of genomic information);
- implementation of genetic evaluation including the use of genomic information; and
- management of genetic variation by maximizing the effective population size or minimizing the rate of inbreeding.

The findings are presented in Table 3C5 (broken down by region), in Table 3C6 (broken down by species) and in the supplementary tables.[3]

The figures presented in the tables show that no breeding goal has been defined for almost half of all reported national breed populations.

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[3] Supplementary tables for Part 3 are provided on CD ROM and at http://www.fao.org/3/a-i4787e/i4787e197.pdf

PART **3**

FIGURE 3C5
State of research in the field of animal breeding
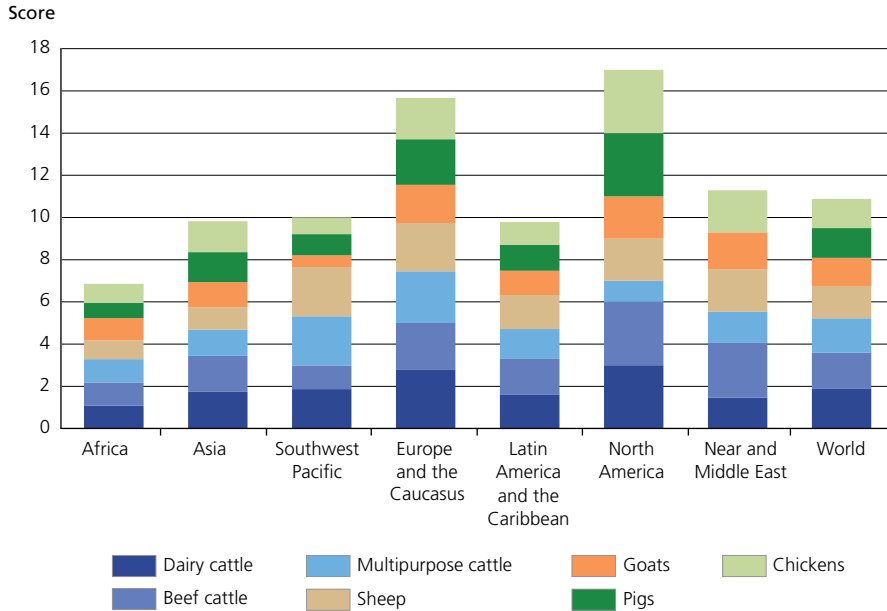
Note: Each country provided a score for the level of provision with respect to each species. The scores were converted into numerical values (none = 0; low = 1; medium = 2; high = 3) and an average score calculated for the respective species × region combinations (countries where the respective species was not reported to be present were excluded from the calculations). The length of each bar corresponds to the cumulative average scores across all species for the respective region. The maximum potential score is 21 (3×7). *Source:* Country reports, 2014.

There are also major gaps in the breed coverage of other fundamental breeding-programme elements, such as animal identification and the recording of pedigrees and performance. Even where activities are reported, their impacts may be limited. The figures give no indication of the level of coverage within the breed population. Given that the management of locally adapted breeds is generally considered to be neglected relative to that of exotic breeds, it is interesting to note that in many cases (i.e. species × technique combinations) coverage is higher among locally adapted breeds than among their exotic counterparts. Two points should be noted in this regard. First, where continuously imported exotic breeds are concerned, the national pop-

ulation is likely to benefit from the effects of breeding programmes operating in other countries, i.e. stakeholders may consider that there is no need to establish a breeding programme at national level (the disadvantage may be a lack of fine-tuning to the needs of local production systems).[4] Second, some of the exotic breeds reported may be present in very small numbers, having been imported by hobbyists or on an

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4 Some locally adapted breeds are present in more than one country. However, international transfers of "improved" breeding animals and genetic material are dominated by a limited number of breeds. In the case of local breeds (i.e. breeds present in only one country) as opposed to transboundary breeds, importing genetic material is not an option as far as straight-breeding is concerned.

TABLE 3C4

Level of organization of livestock keepers with respect to animal breeding activities

Regions and subregions	Number of countries	Dairy cattle	Beef cattle	Multipurpose cattle	Sheep	Goats	Pigs	Chickens
Africa	**40**	**0.8**	**0.6**	**0.8**	**0.7**	**0.7**	**0.6**	**0.7**
East Africa	8	0.9	0.6	0.6	0.3	0.6	0.4	0.9
North and West Africa	20	0.6	0.5	1.0	0.7	0.7	0.6	0.6
Southern Africa	12	1.0	0.8	0.6	0.8	0.8	0.7	0.7
Asia	**20**	**1.5**	**1.1**	**0.6**	**0.9**	**1.0**	**1.2**	**1.3**
Central Asia	4	1.5	0.5	1.0	1.3	1.0	0.3	1.3
East Asia	4	2.5	2.3	0.5	1.0	1.3	2.3	1.8
South Asia	6	0.7	0.2	1.0	0.5	0.7	0.5	0.8
Southeast Asia	6	1.5	1.7	0.0	1.0	1.2	1.7	1.5
Southwest Pacific	**7**	**0.7**	**0.9**	**0.6**	**0.7**	**0.7**	**1.1**	**1.1**
Europe and the Caucasus	**35**	**2.7**	**2.3**	**1.9**	**2.4**	**1.9**	**2.2**	**1.7**
Latin America and the Caribbean	**18**	**1.9**	**1.5**	**0.9**	**1.4**	**1.1**	**1.3**	**1.4**
Caribbean	5	1.8	0.4	0.2	1.2	1.2	1.2	1.0
Central America	5	1.6	1.6	1.2	1.2	1.4	1.4	1.4
South America	8	2.1	2.1	1.1	1.6	0.9	1.4	1.8
North America	**1**	**3.0**	**3.0**	**2.0**	**2.0**	**2.0**	**3.0**	**1.0**
Near and Middle East	**7**	**0.6**	**0.1**	**0.3**	**0.6**	**0.4**	**0.0**	**0.9**
World	**128**	**1.6**	**1.3**	**1.1**	**1.3**	**1.1**	**1.2**	**1.2**

Note: Each country provided a score for the level of organization with respect to each species. The scores were converted into numerical values (none = 0; low = 1; medium = 2; high = 3). The figures shown in the table are average scores for the countries of the respective region.
Source: Country reports, 2014.

experimental basis. These populations may not be intended for use as production animals and therefore the absence of breeding programmes for them may not be particularly significant.

Across almost all the activities covered in Table 3C5, Europe and the Caucasus, North America and the Southwest Pacific[5] are well ahead of the other regions in terms of breed coverage, at

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[5] New Zealand accounts for 56 percent of all the breed populations (cattle, sheep, goats, pigs and chickens) reported from the region and almost all of them are covered by the various breeding-programme elements considered.

least where locally adapted breeds are concerned. Artificial insemination is a partial exception to this rule, a fact that is probably explained, in part, by the species imbalance in the regional figures, i.e. the developed regions have relatively more breeds belonging to species other than cattle. The use of genomic information in genetic evaluation is reported to be very limited everywhere except the Southwest Pacific (because of the responses from New Zealand) and North America. The species breakdown (Table 3C6) shows that for most of the activities described, the highest coverage is in dairy

TABLE 3C5

Level of implementation of breeding-programme elements and techniques – regional breakdown

Regions	Number of national breed populations		Animal identification		Pedigree recording		Performance recording		Artificial insemination	
	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted
			%							
Africa	671	646	48	45	30	29	22	26	37	28
Asia	374	949	48	33	31	24	40	30	40	24
Southwest Pacific	150	66	47	66	41	56	39	61	40	32
Europe and the Caucasus	2 051	2 039	58	78	47	74	41	70	33	32
Latin America and the Caribbean	690	474	37	50	36	35	30	31	31	32
North America	19	222	26	69	26	51	26	46	26	49
Near and Middle East	69	99	30	26	23	16	28	16	20	19
World	**4 024**	**4 495**	**51**	**59**	**40**	**51**	**36**	**49**	**35**	**30**

Regions	Number of national breed populations		Breeding goal defined		Genetic evaluation (classic approach)		Genetic evaluation including genomic information		Management of genetic variation	
	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted
			%							
Africa	671	646	34	39	15	24	9	6	16	13
Asia	374	949	47	26	21	22	6	7	13	11
Southwest Pacific	150	66	48	70	61	54	61	54	53	57
Europe and the Caucasus	2 051	2 039	55	73	29	47	5	8	26	51
Latin America and the Caribbean	690	474	28	30	12	27	4	4	5	8
North America	19	222	26	98	26	40	26	34	26	58
Near and Middle East	69	99	30	18	19	16	1	15	12	5
World	**4 024**	**4 495**	**45**	**53**	**24**	**35**	**8**	**9**	**20**	**32**

Note: The figures refer to the proportion of breeds (national breed populations) belonging to the big five species (cattle, goats, sheep, pigs and chickens) covered by the respective breeding-programme elements and techniques. They provide no indication of population coverage within breeds.
Source: Country reports, 2014.

cattle breeds, beef cattle breeds and sheep breeds. Artificial insemination is again an exception, with multipurpose cattle and pigs having higher coverage than sheep. Chicken breeds have relatively low levels of coverage across all activities, probably reflecting the domination of the chicken subsector by a few high-output breeds and the large number of breeds raised either in backyard systems or by hobbyists.

Countries were also asked to indicate the prevalence (in terms of the number of exotic and locally adapted breed populations covered) of breeding programmes involving straight-breeding only and those involving

TABLE 3C6
Level of implementation of breeding-programme elements and techniques – species breakdown

Species	Number of national breed populations		Animal identification		Pedigree recording		Performance recording		Artificial insemination	
	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted
			%							
Dairy cattle	348	225	69	81	56	68	54	64	81	73
Beef cattle	558	540	76	81	63	76	55	64	65	59
Multipurpose cattle	165	471	84	49	63	37	47	38	78	47
Sheep	605	1 078	76	73	65	65	49	60	28	24
Goats	342	528	61	62	47	46	44	42	27	19
Pigs	401	491	53	56	50	45	47	46	50	33
Chickens	1 605	1 162	23	43	12	36	14	39	10	13
Species	Number of national breed populations		Breeding goal defined		Genetic evaluation (classic approach)		Genetic evaluation including genomic information		Management of genetic variation	
	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted
			%							
Dairy cattle	348	225	45	66	29	54	14	26	29	42
Beef cattle	558	540	54	66	34	51	13	17	25	38
Multipurpose cattle	165	471	61	37	34	28	24	7	33	27
Sheep	605	1 078	60	60	36	41	7	4	31	39
Goats	342	528	49	44	26	27	8	4	25	31
Pigs	401	491	51	45	33	36	11	13	25	29
Chickens	1 605	1 162	33	50	10	25	3	4	9	26

Note: The figures refer to the proportion of breeds (national breed populations) covered by the respective breeding-programme elements and techniques. They provide no indication of population coverage within breeds.
Source: Country reports, 2014.

both straight-breeding and cross-breeding. The responses are summarized for the big five species in Table 3C7. As in the case of the overview figures presented above (Subsection 2) the figures in both categories may be overestimates if a strict definition of the term "breeding programme" is applied. While it is clear that cross-breeding strategies are being pursued in all the regions of the world, in all species and in both breed categories, the nature of these strategies and the extent to which they are linked to straight-breeding programmes is not always clear.

The descriptions provided in the country reports indicate that a strategy of crossbreeding locally adapted breeds or "nondescript" populations with exotic breeds (often through the use of artificial insemination) is being widely pursued in developing countries. In many cases this strategy is being promoted by the country's government as a means of rapidly increasing national output of livestock products.

PART **3**

TABLE 3C7

Proportion of breeds reported to be subject to breeding programmes applying straight/pure-breeding and cross-breeding

Straight/pure-breeding only	Dairy cattle		Beef cattle		Multipurpose cattle		Sheep		Goats		Pigs		Chickens	
	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted
	%													
Africa	38	30	51	46	70	24	24	39	26	38	30	33	25	39
Asia	32	42	15	30	57	43	19	55	24	33	44	17	28	31
Southwest Pacific	10	33	12	38	22	100	0	7	0	0	8	17	0	36
Europe and the Caucasus	42	64	54	48	32	55	54	51	56	56	47	42	12	41
Latin America and the Caribbean	43	53	38	43	0	23	26	27	14	14	20	11	6	27
North America	0	0	0	0	n/a	0	n/a	0	n/a	0	0	0	0	0
Near and Middle East	17	29	0	50	25	13	14	21	27	38	n/a	0	26	21
World	**38**	**48**	**43**	**39**	**40**	**39**	**40**	**45**	**35**	**39**	**35**	**27**	**14**	**35**
Straight/pure-breeding and cross-breeding	Dairy cattle		Beef cattle		Multipurpose cattle		Sheep		Goats		Pigs		Chickens	
	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted	Exotic	Locally adapted
	%													
Africa	57	58	77	54	80	30	36	23	40	32	46	35	25	36
Asia	51	58	31	37	81	15	33	17	47	13	23	15	31	10
Southwest Pacific	80	33	56	63	100	100	96	100	58	86	69	61	81	50
Europe and the Caucasus	23	30	33	37	50	25	26	26	21	11	42	34	30	21
Latin America and the Caribbean	37	47	33	24	40	28	43	37	42	29	39	29	24	12
North America	100	100	100	100	n/a	100	n/a	100	n/a	100	100	100	0	100
Near and Middle East	33	57	0	50	50	33	21	21	18	14	n/a	0	0	0
World	**42**	**47**	**42**	**45**	**64**	**25**	**33**	**30**	**34**	**21**	**41**	**33**	**30**	**23**

Note: n/a indicates that no breed belonging to the respective species and breed category is reported from the respective region. The term "breeds" in the heading refers to national breed populations.
Source: Country reports, 2014.

Well-planned cross-breeding can be an effective means of pursuing this objective. However, if not well planned, the anticipated benefits may not be realized. The extent to which the cross-breeding activities referred to in the country reports form part of organized strategies is not always clear, neither is the extent to which such strategies, where they are in place, are effectively implemented. Consequences in terms of production levels (and in terms of livelihoods, genetic diversity and the environment) are often unmonitored. In all developing regions, a large proportion of countries (75 percent in Africa, 50 percent in Asia, 85 percent in the Southwest

Pacific, 70 percent in Latin America and the Caribbean and 85 percent in the Near and Middle East) report that they have not undertaken an assessment of the impact of the use of exotic breeds.[6]

6 Breeding policies

A majority of countries report that they have national policies in place to support breeding progammes or influence their objectives (Figure 3C6). Dairy cattle breeding (75 percent of countries) is more frequently targeted than the breeding of any other species or type of animal. Chickens are the least targeted species among the big five (53 percent of countries). A number of countries in all regions except North America report the presence of breeding programmes but the absence of any policies in this field. A few countries, in contrast, report that they have no breeding programmes in place, but nonetheless have policies. In the case of most species, breeding policies are more prevalent in developed regions than elsewhere. These policies vary in terms of how much they aim to influence the objectives and implementation of breeding programmes. Some countries (e.g. the United States of America) leave decision-making very much in the hands of the private sector, while others (e.g. European countries, to varying degrees) take a more interventionist approach. Chicken-breeding policies are comparatively rare in Europe and the Caucasus (partly accounting for the low overall coverage of policies targeting this species). Asia has a high level of coverage in several species: 80 percent or higher in dairy and multipurpose cattle, goats, pigs and chickens. Latin America and the Caribbean has a similarly high level of coverage in the case of dairy cattle.

The reported policies vary in terms of their objectives and in terms of the extent to which they are being successfully implemented. As noted above, a number of countries are seeking to promote greater use of exotic breeds and cross-breeding. If not well planned and implemented, policies of this type can contribute to the erosion of locally adapted breeds (see Part 1 Section F).

The Global Plan of Action for Animal Genetic Resources subsumes breeding programmes within the broader field of sustainable use and development (Strategic Priority Area 2) and calls for "national sustainable use polices"[7] and "species and breed development strategies"[8] that take a long-term perspective and consider, *inter alia*, the need to maintain sufficient genetic diversity. Implementation of these elements of the Global Plan of Action is moderately well advanced in terms of the number of countries having sustainable use policies in place (more than 50 percent of reporting countries). Considerable progress since the adoption of the Global Plan of Action in 2007 is reported. A majority of countries (close to 60 percent) also report that they have "long-term sustainable use planning" in place for at least some species and breeds. These figures, however, clearly also indicate that large gaps remain in the coverage of sustainable use policies. National breeding policies are discussed in greater detail in the regional overviews presented below.

7 Regional overviews

7.1 Africa
Breeding programmes in Africa are often based on governmental farms from which breeding animals and/or genetic material are distributed to livestock keepers. The main reported constraints to the development of more effective programmes in this region are a lack of funding, a lack of technical knowledge at all levels and a lack of organizational structures, particularly with respect to livestock-keeper participation in activities

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[6] Figures refer to responses to a specific question addressing this topic included in the section of the country-report questionnaire addressing the state of implementation of the Global Plan of Action.

[7] FAO, 2007b, Strategic Priority 3.
[8] FAO, 2007b, Strategic Priority 4.

FIGURE 3C6

Proportion of countries reporting breeding programmes and policies supporting breeding programmes
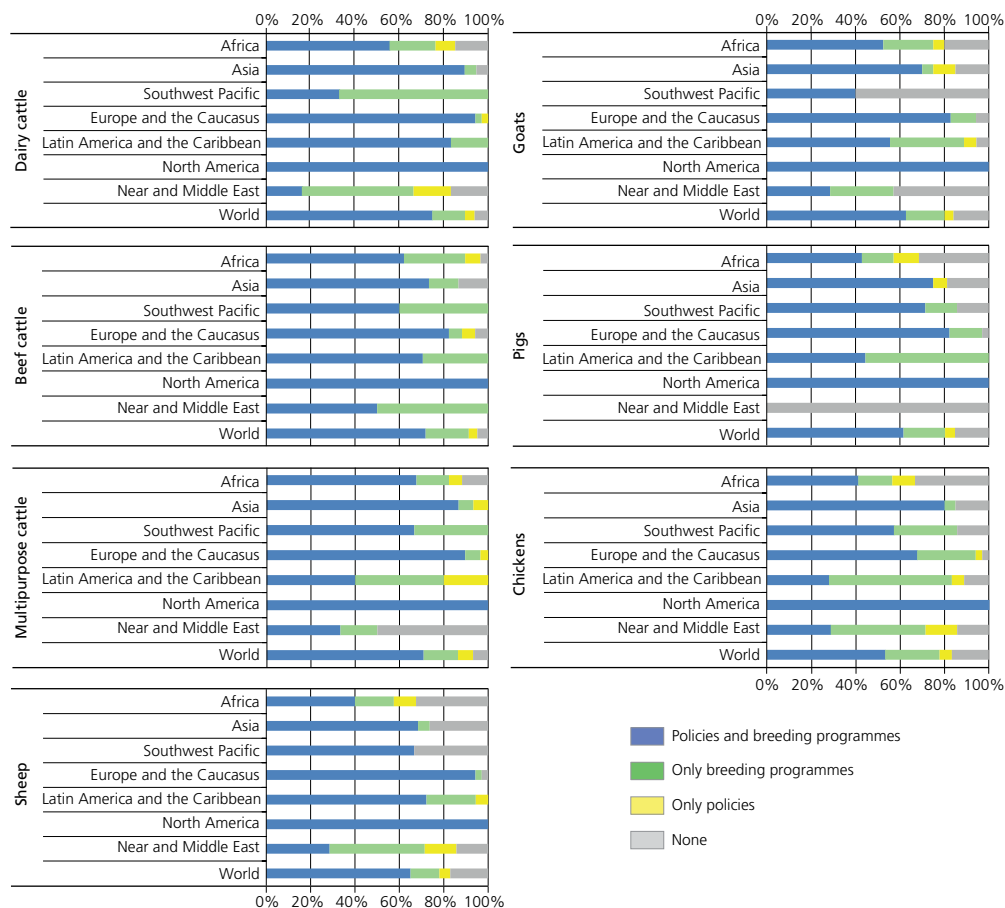
Note: Proportions refer to the proportion of countries reporting the respective species, i.e. countries not reporting the respective species are excluded from calculations.
Source: Country reports, 2014.

such as animal identification and performance recording.

The development of breeders' associations and their involvement in the operation of breeding programmes have generally been limited in Africa, although they are playing an increasing role in some countries. The country report from

South Africa, for example, notes that 72 breed societies "set standards and assist with evaluations" within the framework of the country's national animal-recording and improvement schemes, operated by its Agricultural Research Council's Animal Production Institute. The report from Namibia mentions that breed societies "ensure

Box 3C1
Sheep breeding in Tunisia

In Tunisia, the genetic improvement of sheep is monitored by the Farming and Pasture Office (OEP). Growth records are currently collected in only 109 flocks, via a simplified process involving four weighings. Registered breeds are the Barbarine tête Noire (9 flocks), Barbarine tête Rousse (58 flocks), Noire de Thibar (32 flocks), Queue Fine de l'Ouest (5 flocks) and D'man (5 flocks). The number of registered flocks declined substantially after 2011: firstly, because of civil disturbances, which led to several farms being dissolved, and secondly, because of an attempt to reduce costs. The number of weighings was also reduced as a cost-saving measure. Registered flocks account for roughly 25 000 ewes, a small fraction of the national stock, which was estimated at 3 800 000 ewes in 2011 (Direction Générale de la Production Animale, 2011). Future breeding stocks are selected on the basis of conformation, health and daily-growth traits. Candidate rams and replacement ewes are then sold to breeders and institutional farms nationwide to spread genetic gain. Occasionally, the best rams are used for artificial insemination. On average, genetic gains for growth

traits have been roughly 10 percent of the mean over the last decade. The Sicilo-Sarde dairy breed was recently added to the recording system (five flocks accounting for 100 ewes each). This breed's population size had declined drastically to a few thousand ewes, but has increased to around 29 000 ewes in the last five years following an increase in the price of milk and the establishment of a breed association in the region of Béja in the north of Tunisia. The establishment of breed associations for other breeds is being encouraged, with the aim of supporting breeders, improving breed conservation and alleviating the financial burden on the state, which entirely finances existing improvement programmes. A further objective is to better involve researchers in the characterization and genetic evaluation of breeds and thereby provide a basis for the implementation of robust and durable improvement programmes appropriate for the production systems in the various regions of the country.

Provided by Boulbaba Rekik, National Coordinator for the Management of Animal Genetic Resources, Tunisia.

that their breeders identify animals correctly, determine whether animal recording should be mandatory … and decide whether genetic evaluations should be undertaken." Nonetheless, the majority of the country's livestock keepers are reported not to be involved in any structured breeding programmes. In some countries, breeders' associations have been established, but their practical activities remain at a low level. Rwanda reports that breeders' associations participate in the country's "livestock working group" and that their advice is taken into consideration in the setting of breeding goals. They also play a limited role in animal identification, performance recording and the provision of artificial insemination services in some species.

Some countries report efforts to establish community-based breeding programmes. Where successful

examples of programmes of this kind are reported, they are mainly operated by international research institutions or development NGOs. In Ethiopia, for example, the International Livestock Research Institute (ILRI) and the International Center for Agricultural Research in Dry Areas (ICARDA) have both established some community-based breeding programmes for small ruminants.

Cross-breeding of locally adapted breeds with high-output exotic breeds (often via the use of artificial insemination) is widely reported. The extent to which these efforts are organized or promoted by the government varies from country to country, as does the extent to which steps are taken to minimize the risk of indiscriminate cross-breeding. The country report from Uganda notes that Boer goats (a breed originally imported from South Africa) are raised on government farms and bucks made

available to goat keepers for cross-breeding with their indigenous animals. Goat keepers are trained in how to avoid indiscriminate cross-breeding and also in performance-recording techniques.

7.2 Asia

The design and implementation of breeding programmes in Asia is generally very dependent on the public sector, with research organizations often playing a significant role (Table 3C3). Nonetheless, approaches to the implementation of breeding programmes vary greatly across the region and there are many specificities at country and subregional levels.

In Central Asia, policies that foster cross-breeding with exotic breeds are widespread. In the Islamic Republic of Iran, for example, cross-breeding has been heavily used in dairy cattle, and to a lesser extent in sheep to improve meat production and in goats to improve milk production. The Iranian country report notes that breeding policies will in future continue to promote cross-breeding in dairy cattle, but that in beef cattle, sheep and goats the intention is to give greater attention to the genetic potential of locally adapted breeds. While in some countries livestock keepers are organized into breeders' associations and cooperatives that participate in the implementation of breeding programmes, this is not the case everywhere in the subregion. The country report from Kazakhstan notes that the intention is to concentrate breeding activities on large collective farms. The country also intends to establish a well-organized system for the use of imported genetic material (Box 3C2).

In East Asia, breeding programmes for the main livestock species are in place in the majority of countries. Programmes are government driven, but livestock keepers are well organized in most countries (Tables 3C3 and 3C4). Breeding programmes in Mongolia are less well developed than those in the other reporting countries in this subregion. The country reports two major constraints to the establishment of breeding programmes: the difficulty of organizing pedigree and performance recording in its extensive pro-

duction systems, where livestock are unconfined and mating is usually uncontrolled; and livestock keepers' reluctance to participate in government-driven breeding programmes.

In South and Southeast Asia, governments are also generally quite active in the development of breeding policies and in the implementation of breeding programmes. However, the presence of large numbers of small-scale livestock keepers and the lack of breeders' associations lead to difficulties with the organizational aspects of breeding programmes. Breeding strategies in these subregions usually have a strong focus on cross-breeding with high-output exotic breeds. Governments often facilitate the distribution of breeding material from such breeds. While breeding policies in several countries in these subregions have successfully contributed to increasing production levels, a lack of attention to locally adapted breeds has led to their genetic erosion via indiscriminate cross-breeding and breed replacement. Commercial companies are implementing breeding programmes in some countries, mainly in pigs and chickens. These programmes operate on a small scale, but their importance seems to be growing. The country report from Malaysia, for example, states that future progress will depend on the private sector becoming the main driver of breeding programmes.

7.3 Southwest Pacific

In New Zealand and Australia,[9] breeding programmes are long established and very well developed. Attention is focused largely on the development and improvement of a narrow range of species and breeds. Breeders' associations and livestock keepers' cooperatives play key roles. Breeding programmes are organized by these bodies, and a large proportion of livestock keepers participate in them. Government and research institutions support some activities, but decision-making lies in the hands of the livestock keepers.

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[9] Australia did not submit a country report as part of the second SoW-AnGR process. However, it prepared a country report at its own initiative in 2012.

Box 3C2
Kazakhstan's plan for the development of the beef-cattle industry

Kazakhstan is implementing the "Master Plan for the Development of the Beef Cattle Industry till 2020" with the aim of ensuring the country's supply of protein for human consumption. The main objectives are to:

- increase the numbers of specialized beef cattle;
- increase the proportion of pedigree cattle in the herd (from 8 percent to 20 percent); and
- increase slaughter weights and dressing percentage.

It is planned to import 72 000 animals from highly productive beef breeds. During the period between 2010 and early 2014, 45 000 pedigree beef animals were imported from the United States of America (34 percent), Australia (22 percent), Canada (14 percent), the countries of the European Union (21 percent) and the Russian Federation (8 percent). The programme aims to increase the population of female beef cattle to 1.5 million head by 2020, with annual delivery of more than 900 000 animals for slaughter and annual beef production of more than 200 000 tonnes.

To accomplish these objectives, the Government of Kazakhstan is considering, *inter alia*, introducing:

- preferential credit and subsidies for the purchase of imported pedigree cattle;
- investing in farm machinery and equipment;
- providing interest-rate subsidies for selective breeding;
- decreasing the costs of forage production; and
- subsidizing the construction of modern feedlots.

The imports have led to some negative consequences, such as deaths of cattle from exotic disease, and reduced reproductive and productive rates because of the need to acclimatize to the new production environment.

It is planned to bring the share of imported cattle in the total beef breeding herd up to 40 to 50 percent. Currently, imported livestock are used both for pure-breeding and for cross-breeding. Positive results have been obtained by crossing the Kazakh White-headed breed with the Hereford, the Auliyekol with the Charolais, and the zonal type "Zhetysu" with the Limousin. Negative impacts on locally adapted breeds are possible if massive uncontrolled cross-breeding occurs.

Provided by Talgat Karymsakov, National Coordinator for the Management of Animal Genetic Resources, Kazakhstan.

In the small island countries of the Southwest Pacific, breeding programmes are rare and where they exist are in their early stages of development (it should be noted in this context that given the small size of these countries attempting to establish independent breeding programmes is not necessarily an appropriate strategy). Livestock-keeper organizations are not well developed and the few breeding programmes mentioned in the country reports are government driven. Private companies are sometimes involved, but there is little participation on the part of individual breeders. The most commonly reported activity is the importation and distribution of exotic breeds to replace locally adapted breeds or for cross-breeding with them. The country report from Samoa describes plans to involve large commercial farms as multipliers within a pyramidal breeding system as a means of meeting demand for breeding animals. The multipliers will be supplied with breeding animals from government-run nucleus farms, and in turn supply individual farmers.

7.4 Europe and the Caucasus

In the majority of the countries of Europe and the Caucasus, the livestock sector is well developed, and breeding programmes are long established and well organized (Tables 3C4 and 3C5 and Figure 3C6). In most European countries, breeders' associations are well organized and play a key role in the operation of breeding programmes (Table 3C3). In a number of countries

Box 3C3
Using exotic genetics in the dairy sector – experiences from Poland

Cattle breeding work undertaken in Poland after the Second World War focused on dual-purpose cattle. All breeds were used for both milk and meat production. The majority of cattle belonged to the Black and White and Red and White lowland breeds, with the Polish Red breed also making up a substantial proportion of the population. In this period, only 20 percent of the cattle population was kept on large-scale farms, while farms keeping one or two cows accounted for 40 percent (Trela and Choroszy, 2010).

The first national programme for the evaluation and selection of bulls for use in artificial insemination was introduced in 1971. Initially, the breeding value of the bulls was estimated using contemporary comparison. Best Linear Unbiased Prediction (BLUP) was introduced in 1985, and BLUP-Animal Model in 1991. The Programme on Genetic Improvement of Cattle Performance, introduced in 1972, with a timeframe running till 1990, underlined the importance of artificial insemination, including the use of imported semen (which came mainly from the United States of America, Canada and Western Europe).

Before 1985, very little genetic progress was achieved within the national breeding scheme and therefore there was an urgent need for an alternative approach. The "Programme on Cattle Breeding and Production to 2000", adopted in 1986, for the first time accepted backcrossing with Holstein-Friesian bulls as a way of developing a specialized dairy population. This was to be complemented by ongoing improvement of pure-bred dual-purpose cattle. Backcrossing with Holstein-Friesians presented an opportunity to benefit from the high genetic potential of this specialized dairy breed and to rapidly enhance the genetic value of the national cattle stock. Over time, as farmers' demand for high-performing dairy stock grew, the development of the herd-book population became dependent on the import of Holstein-Friesian semen. However, the general use of Holstein-Friesian semen was not promoted, as a large part of the cattle population was kept in small herds (up to five cows) under modest husbandry conditions.

After the introduction of the market economy in 1990, the rapid development of the dairy processing sector facilitated the development of specialized dairy production and as a result backcrossing with Holstein-Friesians became widespread. The greater availability of imported semen contributed to this development. As a result of long-term continuous backcrossing, the active Black and White cattle population was completely replaced with the Holstein-Friesian genotype. This led to the recognition of a new breed, the Polish Holstein-Friesian, for which herd books were established in 2005 by the Polish Federation of Cattle Breeders and Dairy Farmers.

To maintain the genetic resources of the traditional dual-purpose types of Polish cattle, the Polish Black and White and the Polish Red and White, were included in the genetic resources conservation programme, as had been already been done for the Polish Red and Whitebacked breeds. This enabled the continued production of semen for use on farms where conditions are not suitable for the highly demanding Polish Holstein-Friesian cows.

The widespread use of Holstein-Friesian semen resulted in the transformation of the dual-purpose population into a specialized dairy breed, and enabled an increase in national milk production while reducing the number of cows (5.5 million in 1985 and 2.4 million in 2013). In 2013, the average milk yield of the Polish Holstein-Friesian Black and White variety was 7 588 kg and that of the Red and White variety was 6 936 kg, while those of the Polish Black and White and the Polish Red and White breeds were 4 659 kg and 4 610 kg respectively (PFHBPM, 2013). It is clear that cross-breeding with an exotic highly specialized dairy breed has positively affected overall milk production. However, high performance was accompanied by decreased fertility, higher somatic cell counts, poor leg conformation and reduced herd-life (Pokorska *et al.*, 2012), problems that are common in the Holstein-Friesian population worldwide. To address these issues, the breeding goals within the programme were substantially widened in 2007. Moreover, in some commercial herds limited cross-breeding with Montbeliarde or Swedish/Norwegian Red cattle was initiated to improve health and robustness.

Provided by Elżbieta Martyniuk, National Coordinator for the Management of Animal Genetic Resources, Poland.

(e.g. the Netherlands, Norway and the United Kingdom) the government's role in breeding programmes is largely restricted to providing support to breeders' associations via research activities. Generally, governments supervise and monitor the implementation and performance of breeding programmes. They implement animal-identification schemes in which all livestock keepers have to participate regardless of whether or not they are members of breeders' associations. They also support breeders' associations by coordinating their work. Some countries (e.g. France and Spain) provide subsidies to support the work of breeders' associations. Breeders' associations organize and implement performance and pedigree recording, set and review breeding goals, ensure the consistency of activities contributing to the genetic improvement of the breed and, where they have the capacity, implement genetic evaluations. Research institutes and universities support breeders' associations and governments in the theoretical and methodological aspects of genetic evaluation, as well as working on the development and refinement of breeding methods. There is, however, some variation across the region. In some countries, particularly in the Caucasus and parts of southeastern Europe, breeding programmes are relatively undeveloped, livestock-keeper organization is limited and breeders' associations are rare.

Commercial companies are active in the region's dairy cattle and pig-breeding sectors and dominate the poultry-breeding sector. They control most of the market for genetic resources in these sectors and work with a narrow range of breeds and lines. As a result of this focus, their roles in breeding programmes for locally adapted breeds of pigs, chickens and dairy cattle are usually limited.

Many European countries rely, to varying degrees, on the use of imported genetics. A number of countries report that this poses a threat to the survival of some of their locally adapted breeds (see Part 1 Section F). However, in some countries it has proved possible to combine a programme of development based on the use of exotic breeds with measures that ensure that locally adapted breeds are maintained and that appropriate genetic resources for use in more marginal production environments remain available (see, for example, Box 3C3).

7.5 Latin America and the Caribbean

In Latin America and the Caribbean, breeding programmes are diverse in terms of the stakeholder groups involved in organizing and implementing them. Depending on the country and the species, breeding programmes may be operated by governments, breeders' associations, commercial companies or livestock keepers organized at community level. However, some stakeholders are more important that others in terms of the implementation of specific breeding-programme elements. Governments are very active in the operation of animal-identification schemes. Breeders' associations and individual livestock keepers are heavily involved in the definition of breeding goals and in the recording of performance data. Artificial insemination is mainly delivered by commercial companies. Research institutions are heavily involved in genetic evaluations.

In the Caribbean, breeding programmes are less developed than in Central and South America. Governments are the main operators of the few breeding programmes that are in place. The importation of exotic genetic material for cross-breeding with locally breeds is widespread. The best-developed breeding programmes are in the dairy-cattle sector, which is characterized by a relatively high level of livestock-keeper organization and the presence of commercial companies. The country report from Suriname, for example, notes that dairy cooperatives actively participate in the definition of breeding goals and also facilitate the provision of artificial insemination services. The report from Trinidad and Tobago mentions that a national commercial dairy company provides artificial insemination to some dairy farms, although on an irregular basis, and also records production data for some farms.

PART 3

Box 3C4
Beef cattle breeding in Brazil

As well as having the largest commercial cattle herd in the world, Brazil is currently the world's largest exporter of beef. In recent decades, breeding programmes have been at the forefront of beef-sector development and have achieved a marked increase in the productivity of beef breeds.

In 2003, when Brazil prepared its country report for the first report on *The State of the World's Animal Genetic Resources for Food and Agriculture*, there were 16 breeding programmes operating in the beef sector,[1] and they all remain operational. Thirteen programmes target various Zebu breeds, with the objective of increasing reproductive efficiency and growth rate using classical breeding techniques allied with modern biotechnologies. Two further programmes are the Breeding Programme for Zebu Cattle (PMGZ) and GENEPLUS. PMGZ is run by the Brazilian Zebu Breeders' Association, which identifies superior animals by calculating expected progeny differences (EPDs) for weight and weight gain at various ages, as well as for fertility traits and reproductive efficiency, based on a national database covering all Zebu breeds. GENEPLUS provides zebu breeders with EPDs for various production and reproductive traits. The oldest Brazilian herd book, created in 1906, the Collares Herd Book, is responsible for the registration of British and continental cattle breeds, and operates PROMEBO, a genetic evaluation programme for seven *Bos taurus* breeds, which provides yearly sire summaries with EPDs for weights and reproductive traits.

One of the main successes has been a switch from selection for qualitative traits (e.g. ear size in Zebu cattle) to selection for quantitative traits with a more direct link to productivity. Since 2003, the number of animals recorded in the database of the PMGZ programme has risen from 1.5 million animals to 3.6 million animals, with 230 000 new animals entering the database each year. GENEPLUS today covers five Zebu breeds and four composite breeds, as well as two European breeds. Its database, which covered about 700 000 animals in 2003, now covers more than 2.5 million animals. Despite the successes, breeding programmes in Brazil still face many constraints. In the poorer regions of the country, the main constraints are:

- a lack of farmer awareness and commitment to recording animal performance;
- a low level of education among livestock keepers; and
- the cost of recording for smallholders, especially in the case of locally adapted breeds.

Future priority objectives for breeding programmes include, in addition to continuing to increase meat production, increasing dam longevity and meat quality. In Zebu cattle, meat tenderness is fundamental to maintaining export levels, especially exports to countries with higher quality requirements.

Provided by Arthur Mariante, National Coordinator for the Management of Animal Genetic Resources, Brazil.
[1] See FAO 2007a, Box 31 (page 231).

The majority of breeding programmes in Central and South America are implemented by breeders' associations or commercial companies. Breeders' associations generally receive support from the public sector, mainly via the work of research institutions, which are involved not only in genetic evaluation, but also on definition of breeding goals, in performance recording and in the organizational aspects of breeding programmes. Commercial companies – mainly national, but in some cases international – are very active in the region and operate breeding programmes for dairy and beef cattle, pigs and chickens, and to a lesser extent goats. The country report from Costa Rica notes that experiences gained in the implementation of cattle-breeding programmes are used to guide the development of programmes for small-ruminant species.

Cross-breeding strategies are reported to be quite widespread in Latin America (Table 3C7).

Companies and research institutes have developed composite lines, mostly in beef cattle, but also in other species. Cross-breeding with exotic breeds (using both imported genetic material and genetic material sourced from within the region), and to a lesser extent with composite lines developed in the region, is widely used as a method of increasing production levels. Brazil reports a major increase in livestock productivity over recent years, brought about by the implementation of well-developed breeding programmes (Box 3C4). Research organizations at national and regional levels, as well as universities and breeders' associations, are responsible for the majority of Brazil's breeding programmes. In other countries (e.g. Chile, Ecuador and Paraguay), improvement of animal performance has been based on the importation of genetic material and efforts to establish breeding programmes for various livestock species are currently ongoing. Peru and the Plurinational State of Bolivia have established breeding programmes aimed at improving fibre quality in llamas and alpacas. Bolivian programmes include some operated by community-owned companies, the main such company, COPROCA, involves 1 200 camelid keepers. Peru reports breeding programmes for several "minor" species, including rabbits, ducks and guinea pigs.

7.6 North America
In the United States of America, breeding programmes are technologically advanced and widely implemented in all the main livestock species. Cross-breeding strategies are widespread (Table 3C7). Breeders' associations and individual livestock keepers are the main stakeholders involved in the operation of breeding programmes (Table 3C3). National and international commercial companies play a major role in cattle, pig and chicken breeding programmes. Advanced technologies such as genomic selection are widely used in dairy cattle breeding (see supplementary table A3C8).[10] Decision-making regarding breed-ing activities rests with livestock keepers or commercial companies. Federal and state research organizations may develop means of evaluating traits that the livestock industry deems important, but responsibility for adapting and utilizing such approaches lies with the industry.

7.7 Near and Middle East
The coverage and state of development of breeding programmes in the Near and Middle East are very limited. The programmes that do exist mainly involve sheep and goats and are based on governmental farms or breeding stations. The involvement of livestock keepers is very limited (see Box 3C5 for example). Selected animals, raised on governmental farms or imported, are distributed to livestock keepers with the aim of increasing production levels. Artificial insemination programmes operate on a limited scale.

Box 3C5
Sheep breeding in Jordan

Jordan's sheep-breeding programmes are conducted on a very limited scale. Breeding stations distribute some selected rams to livestock keepers, without measuring the animals' productivity under field conditions and without monitoring. The majority of these rams are selected phenotypically, without genetic-evaluation programmes.

A national animal identification and registration system is in place, but there is no performance and pedigree recording at the livestock-keeper level. To establish a breeding programme at national level, animal identification needs to be linked to performance and pedigree information. Establishing such a programme would require well-qualified staff and good collaboration among stakeholders.

Source: Adapted from Jordan's country report.

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[10] Supplementary tables for Part 3 are provided on CD ROM and at http://www.fao.org/3/a-i4787e/i4787e197.pdf

PART **3**

8 | Changes since 2005

As noted in the introduction to this section, many of the data presented above are not directly comparable to those presented in the first SoW-AnGR. However, in both reporting processes countries provided information on the number of breeds subject to various breeding-related activities. The list was slightly expanded for the second reporting process, but results for the activities covered in both processes are presented in Figure 3C7 (for cattle breeds).

Because the first reporting process was not based on a structured questionnaire,[11] comparable figures are available for only 35 countries.[12] The results show that – at least as far as the 35 countries are concerned – the proportion of cattle breeds covered by all the various breeding-related activities reported upon has expanded since the time of the first SoW-AnGR reporting process. Is should, however, be noted that there are some differences between the pattern of development in OECD countries and that in non-OECD countries. In particular, coverage of genetic evaluation has increased much more sharply in OECD countries (46 percent to 70 percent) than in non-OECD countries, where it has remained almost stable at around 32 percent. Given the progress made in the implementation of other breeding-programme elements, addressing the coverage of genetic evaluations would appear to be the logical next step towards the more widespread establishment of effective breeding programmes.

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[11] During the first SoW-AnGR process, countries were provided with predefined tables or "tabulation tools", intended to facilitate the collection and analysis of information during the preparation of their country reports. Some countries included the completed tables in their country reports, while others did not.

[12] Albania, Argentina, Austria, Bangladesh, Benin, Brazil, Burundi, Cameroon, Croatia, Cyprus, Democratic Republic of the Congo, Ethiopia, Gambia, Ghana, Greece, Guatemala, Iceland, Latvia, Lesotho, Madagascar, Malaysia, Mexico, Namibia, Norway, Paraguay, Republic of Korea, Senegal, Slovakia, Slovenia, Swaziland, Sweden, Togo, Ukraine, United Republic of Tanzania and Uruguay.

9 | Conclusions and priorities

While the majority of countries report that they have at least some breeding progammes in place, the reported levels of implementation of the various elements of breeding programmes suggest that these programmes are often in a very rudimentary state – or in some cases non-existent in the sense of organized progammes involving the establishment of breeding goals, recording of performance, etc.

The involvement of stakeholder groups in the organization and implementation of breeding programmes varies greatly from region to region. In Africa, Asia and the Near and Middle East, governments are the main players, while in North America, Europe and the Caucasus, Australia and New Zealand, responsibility for operating breeding programmes lies mainly in the hands of breeders' associations and commercial companies, with various degrees of support from governments and research organizations, depending on the country. The involvement of breeders' associations and commercial companies is also relatively well developed in parts of Latin America.

The first SoW-AnGR concluded that, where they existed, government-operated breeding programmes in developing countries tended to have limited impact because of a lack of interaction with livestock keepers. However, it also concluded that there were many constraints to the emergence of the "developed-country" model based on breeders' associations and involving minimal governmental support, particularly with regard to the organizational structures needed to facilitate the involvement of individual livestock keepers and the relatively high levels of knowledge and technical skills required. The information provided in the country reports suggests that a number of these preconditions have still not been met in many countries. While there are some reported examples of progress, livestock-keeper organization frequently remains poorly developed, as do education and training in the field of livestock breeding.

Many countries have put policies in place aimed at improving the state of livestock breeding.

FIGURE 3C7
Implementation of breeding tools in cattle (2005 and 2014)

Percentage of cattle breeds (national breed populations)
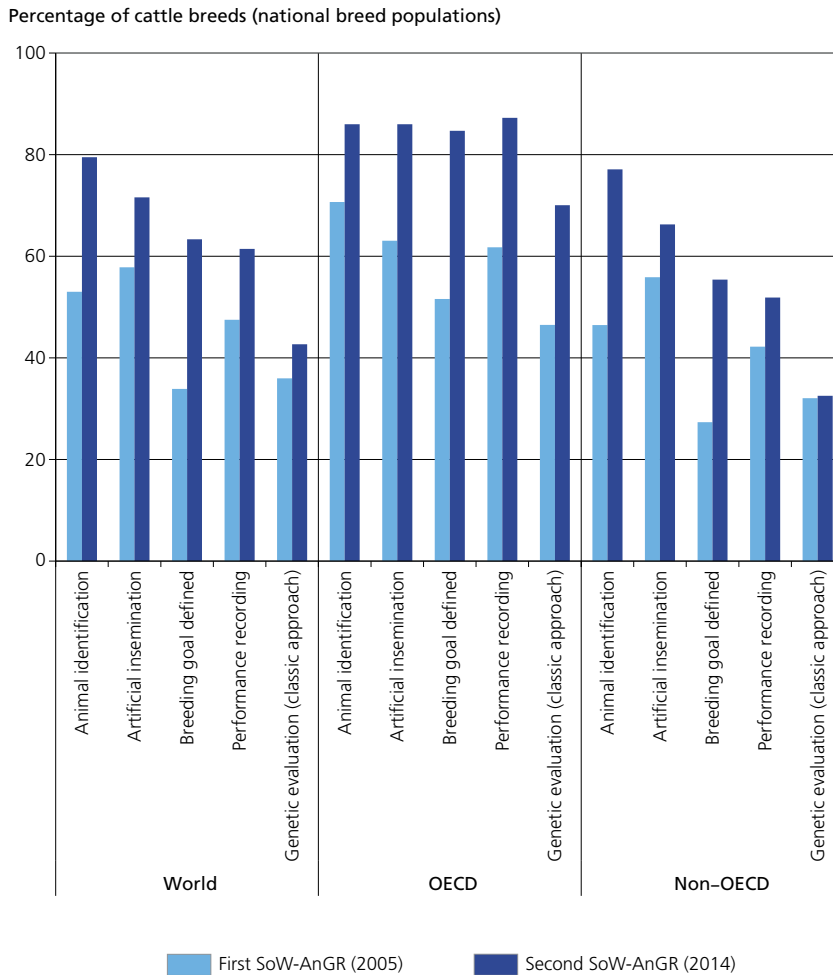
Note: The figure is based on information reported by the 35 countries (9 OECD and 26 non-OECD) that provided the relevant information in both State of the World (SoW-AnGR) reporting processes. The figures represent the percentage of cattle breeds (national breed populations) in which the tools are used. Note that they may be used only in part of the population within these breeds.

In many developing countries, in particular, these policies focus mainly on the introduction of exotic breeds for use in cross-breeding, sometimes with little attention to the establishment of breeding programmes. Utilizing the genetic progress already made in exotic breeds has obvious attractions for countries seeking rapidly to boost their output of livestock products. The difficulty lies in the fact that while increasing the availability of exotic genetic material may be relatively straightforward, ensuring that it is used appropriately is more challenging.

While interest in expanding the use of exotic breeds is practically universal in developing countries, a number have also recognized the need to take greater advantage of the characteristics of their locally adapted breeds, particularly given the challenges associated with climate change and the ongoing need for livestock that are suitable for use by small-scale producers and in low-input production systems. In this context, improving the productivity of locally adapted breeds through the implementation of breeding programmes is, at least in theory, an appealing option, both because of the potential to derive benefits directly from increasing livestock productivity and because it may help to keep the breeds in use and hence available as resources for the future. However, for the reasons noted above, implementing such programmes is often challenging. Only a small number of developing countries report the successful establishment of community-based breeding programmes in medium- or low-input production systems.

On the positive side, the evidence provided in the country reports suggests that the level of implementation of several of the main elements of breeding programmes – in terms of the number of breeds covered – has increased in recent years. Major gaps, nonetheless, remain in all developing regions. Even where activities are reported to have become more widespread in terms of breed coverage, they may remain very restricted in terms of the proportion of the population covered within each breed. Animal identification appears to be the area where the most progress has been made, probably because of its multiple roles in livestock development.

As noted in the first SoW-AnGR, developing a national breeding strategy can be very challenging, particularly given that the information needed in order to assess the relative costs and benefits of different approaches is often unavailable. The existence of these knowledge gaps underlines the importance of strengthening efforts to characterize breeds and their production environments (see Part 3 Section B and Part 4 Sections A and B) and the need to keep track of trends and drivers of change in the livestock sector (see Part 2).

Countries have a range of different short- and longer-term objectives and often have to deal with a diverse range of production systems. Identifying specific priorities at national and production-system levels is therefore a matter for countries themselves. The information provided in the country reports suggests that, in more general terms, priorities will often include capacity-building at all levels from livestock-keepers to policy-makers, as well as strengthening the organizational structures needed in order to implement successful breeding programmes. Livestock-keeper involvement is frequently a weak point in existing programmes.

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