



**Food and Agriculture  
Organization of the  
United Nations**

COMMISSION ON  
GENETIC RESOURCES  
FOR FOOD AND  
AGRICULTURE

ISSN 2412-5474



THE SECOND REPORT  
ON THE STATE  
OF THE WORLD'S  
**ANIMAL GENETIC RESOURCES FOR  
FOOD AND AGRICULTURE**

**FAO COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE**  
ASSESSMENTS • 2015



FAO COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE  
ASSESSMENTS • 2015

THE SECOND REPORT  
ON THE STATE  
OF THE WORLD'S  
**ANIMAL GENETIC RESOURCES FOR  
FOOD AND AGRICULTURE**

COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE  
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Rome, 2015

**Recommended citation:**

FAO. 2015. *The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture*, edited by B.D. Scherf & D. Pilling. FAO Commission on Genetic Resources for Food and Agriculture Assessments. Rome (available at <http://www.fao.org/3/a-i4787e/index.html>).

The designations employed and the presentation of material in this information product do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations (FAO) concerning the legal or development status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The mention of specific companies or products of manufacturers, whether or not these have been patented, does not imply that these have been endorsed or recommended by FAO in preference to others of a similar nature that are not mentioned.

The designations employed and the presentation of material in the map(s) do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal or constitutional status of any country, territory or sea area, or concerning the delimitation of frontiers.

ISBN 978-92-5-108820-3

© FAO, 2015

FAO encourages the use, reproduction and dissemination of material in this information product. Except where otherwise indicated, material may be copied, downloaded and printed for private study, research and teaching purposes, or for use in non-commercial products or services, provided that appropriate acknowledgement of FAO as the source and copyright holder is given and that FAO's endorsement of users' views, products or services is not implied in any way.

All requests for translation and adaptation rights, and for resale and other commercial use rights should be made via [www.fao.org/contact-us/licence-request](http://www.fao.org/contact-us/licence-request) or addressed to [copyright@fao.org](mailto:copyright@fao.org).

FAO information products are available on the FAO website ([www.fao.org/publications](http://www.fao.org/publications)) and can be purchased through [publications-sales@fao.org](mailto:publications-sales@fao.org).

# Contents

Foreword	xxi
Acknowledgements	xiii
Abbreviations and acronyms	xxvii
About this publication	xxix
Summary	xxxvii

## Part 1 The state of livestock diversity

---

### Introduction

<b>SECTION A: ORIGIN AND HISTORY OF LIVESTOCK DIVERSITY</b>	<b>5</b>
1 Introduction	5
2 The domestication process	5
3 Dispersal of domesticated animals	10
4 Introgression from related species	12
5 Adaptation of livestock following domestication	12
6 The recent history of livestock diversity	13
7 Conclusions	15
References	16
<b>SECTION B: STATUS AND TRENDS OF ANIMAL GENETIC RESOURCES</b>	<b>25</b>
1 Introduction	25
2 The state of reporting	25
3 Species diversity and distribution	26
4 Breed diversity and distribution	30
5 Conclusions	41
References	42
<b>SECTION C: FLOWS OF ANIMAL GENETIC RESOURCES</b>	<b>43</b>
1 Introduction	43
2 Status and trends of global gene flows	45
3 Drivers of gene flow in the twenty-first century	57
4 Effects of gene flows	60
5 Conclusions	62
References	62
<b>SECTION D: ROLES, USES AND VALUES OF ANIMAL GENETIC RESOURCES</b>	<b>65</b>
1 Introduction	65
2 Contributions to food production, livelihoods and economic output	66
3 Sociocultural roles	72

4	Ecological roles – the provision of regulating and habitat ecosystem services	73
5	Roles in poverty alleviation and livelihood development	75
6	Conclusions and research priorities	78
	References	79
<b>SECTION E:</b>	<b>ANIMAL GENETIC RESOURCES AND ADAPTATION</b>	<b>83</b>
1	Introduction	83
2	Global information on adaptations	83
3	Adaptation to non-disease stressors	85
4	Disease resistance and tolerance	89
5	Conclusions and research priorities	100
	References	101
<b>SECTION F:</b>	<b>THREATS TO LIVESTOCK GENETIC DIVERSITY</b>	<b>109</b>
1	Introduction	109
2	Livestock sector trends	110
3	Disasters and emergencies	126
4	Animal disease epidemics	133
5	Conclusions	135
	References	137
<b>SECTION G:</b>	<b>LIVESTOCK DIVERSITY AND HUMAN NUTRITION</b>	<b>143</b>
1	Introduction	143
2	Growing interest in food biodiversity	143
3	Filling the knowledge gap	145
4	Potential significance for human nutrition	146
5	Research priorities	149
	References	150

## Part 2 Livestock sector trends

---

Introduction

<b>SECTION A:</b>	<b>DRIVERS OF CHANGE IN THE LIVESTOCK SECTOR</b>	<b>157</b>
1	Introduction	157
2	Changes in demand	157
3	Changes in trade and retailing	162
4	Changing natural environment	166
5	Advances in technology	170
6	Policy environment	171
	References	174

<b>SECTION B:</b>	<b>THE LIVESTOCK SECTOR'S RESPONSE</b>	<b>179</b>
	1 Landless industrialized production systems	180
	2 Small-scale landless systems	184
	3 Grassland-based systems	185
	4 Mixed farming systems	187
	References	189
<b>SECTION C:</b>	<b>EFFECTS OF CHANGES IN THE LIVESTOCK SECTOR ON ANIMAL GENETIC RESOURCES AND THEIR MANAGEMENT</b>	<b>193</b>
	1 Overview and regional analysis	193
	2 Specific effects on animal genetic resources management – examples at country level	199
	References	205
<b>SECTION D:</b>	<b>LIVESTOCK SECTOR TRENDS AND ANIMAL GENETIC RESOURCES MANAGEMENT – CONCLUSIONS</b>	<b>207</b>
	References	208

## Part 3 The state of capacities

---

### Introduction

<b>SECTION A:</b>	<b>INSTITUTIONS AND STAKEHOLDERS</b>	<b>213</b>
	1 Introduction	213
	2 Institutional capacities at country level	214
	3 Institutional frameworks at subregional and regional levels	226
	4 Institutional frameworks and stakeholders at international level	228
	5 Changes since 2005	230
	6 Conclusions and priorities	235
	References	235
<b>SECTION B:</b>	<b>CHARACTERIZATION, INVENTORY AND MONITORING</b>	<b>237</b>
	1 Introduction	237
	2 Development of national breed inventories	237
	3 Baseline surveys and monitoring of population sizes	238
	4 Phenotypic and molecular genetic characterization	240
	5 Constraints to characterization, surveying and monitoring	246
	6 Conclusions and priorities	249
	References	250

<b>SECTION C:</b>	<b>BREEDING PROGRAMMES</b>	<b>251</b>
	1 Introduction	251
	2 Global overview	251
	3 Stakeholder involvement	253
	4 Educational, research and organizational capacities	257
	5 Breeding methods and activities	259
	6 Breeding policies	265
	7 Regional overviews	265
	8 Changes since 2005	274
	9 Conclusions and priorities	274
	References	276
<b>SECTION D:</b>	<b>CONSERVATION PROGRAMMES</b>	<b>277</b>
	1 Introduction	277
	2 Global overview	277
	3 <i>In situ</i> conservation programmes – elements	281
	4 <i>In situ</i> conservation programmes – the roles of the public and private sectors	291
	5 <i>Ex situ in vitro</i> conservation programmes	295
	6 Regional overviews	297
	7 Changes since 2007	306
	8 Conclusions and priorities	307
	References	307
<b>SECTION E:</b>	<b>REPRODUCTIVE AND MOLECULAR BIOTECHNOLOGIES</b>	<b>309</b>
	1 Introduction	309
	2 Global overview	310
	3 Stakeholders involved in service provision and research	316
	4 Regional overviews	317
	5 Changes since 2005	326
	6 Conclusions and priorities	327
	References	328
<b>SECTION F:</b>	<b>LEGAL AND POLICY FRAMEWORKS</b>	<b>329</b>
	1 Introduction	329
	2 International frameworks	329
	3 Regional frameworks	340
	4 National frameworks	355
	5 Changes since 2005	403
	6 Gaps and needs	404
	References	405

## Part 4 The state of the art

---

Introduction

<b>SECTION A: CHARACTERIZATION, INVENTORY AND MONITORING</b>	<b>415</b>
1 Introduction	415
2 Characterization as the basis for decision-making	416
3 Tools for characterization, surveying and monitoring	419
4 Information systems	423
5 Changes since 2005	426
6 Conclusions and research priorities	427
References	429
<b>SECTION B: MOLECULAR TOOLS FOR EXPLORING GENETIC DIVERSITY</b>	<b>431</b>
1 Introduction	431
2 Developments in the use of DNA markers	433
3 Characterization of within-population diversity	435
4 Characterization of between-population diversity	436
5 Molecular tools for targeting functional variation	437
6 The role of bioinformatics	440
7 Conclusions and research priorities	441
References	442
<b>SECTION C: BREEDING STRATEGIES AND PROGRAMMES</b>	<b>451</b>
1 Introduction	451
2 Scientific and technological advances	452
3 The elements of a breeding programme	457
4 Breeding programmes in high-input systems	459
5 Breeding programmes in low-input systems	474
6 Conclusions and research priorities	482
References	485
<b>SECTION D: CONSERVATION</b>	<b>497</b>
1 Introduction	497
2 Planning a conservation strategy	501
3 Identifying breeds at risk	501
4 Determining the conservation value of a breed	503
5 <i>In vivo</i> conservation	504
6 Cryoconservation	511
7 Conclusions and research priorities	522
References	523



<b>SECTION E: ECONOMICS OF ANIMAL GENETIC RESOURCES USE AND CONSERVATION</b>	<b>529</b>
1 Introduction	529
2 Developments in animal genetic resources economics	531
3 Challenges and opportunities	539
References	541

## **Part 5** Needs and challenges

---

Introduction	
<b>SECTION A: CHALLENGES POSED BY LIVESTOCK SECTOR TRENDS</b>	<b>553</b>
<b>SECTION B: CHARACTERIZATION AND MONITORING</b>	<b>555</b>
<b>SECTION C: SUSTAINABLE USE AND DEVELOPMENT</b>	<b>557</b>
<b>SECTION D: CONSERVATION</b>	<b>559</b>
<b>SECTION E: POLICIES, INSTITUTIONS AND CAPACITY-BUILDING</b>	<b>561</b>

## **Annexes** (on CD-ROM and on the web at <http://www.fao.org/3/a-i4787e/index.html>)

---

Country reports  
 Survey responses – national legal and policy frameworks  
 Reports from regional focal points and networks  
 Reports from international organizations  
 Thematic studies  
 Supplementary tables for Part 3  
 List of references reviewed for Part 4 Section E – Economics  
 of animal genetic resources use and conservation  
 List of authors, reviewers and their affiliations

## BOXES

<b>1</b>	The first report on <i>The State of the World's Animal Genetic Resources for Food and Agriculture</i> (2007)	xxix
<b>2</b>	The Commission on Genetic Resources for Food and Agriculture	xxx

### **PART 1**

---

<b>1A1</b>	How the history of livestock is reconstructed: archaeology and DNA	6
<b>1A2</b>	Livestock diversity as revealed by molecular studies	15
<b>1B1</b>	Developments since the publication of the first report on <i>The State of the World's Animal Genetic Resources for Food and Agriculture</i>	26
<b>1B2</b>	Glossary: populations, breeds, breed classification systems and regions	27
<b>1B3</b>	Glossary: risk-status classification	34
<b>1C1</b>	Trends in gene flows into and out of Kenya	50
<b>1C2</b>	Gene flows into and out of Thailand	50
<b>1C3</b>	Gene flows into Senegal	51
<b>1C4</b>	Gene flows into and out of South Africa	52
<b>1C5</b>	Gene flows between Uganda and other developing countries	54
<b>1C6</b>	Brazil's role as an exporter of genetic resources	55
<b>1C7</b>	Influence of policies on gene flows into Cameroon	58
<b>1C8</b>	Effect of a disease outbreak on inward gene flow – an example from the Republic of Korea	59
<b>1D1</b>	Categories of ecosystem services	74
<b>1D2</b>	The use of livestock in the provision of ecosystem services – examples from the United States of America	75
<b>1D3</b>	A special sheep breed helps to preserve centuries-old grassland in the Alps	76
<b>1D4</b>	The use of livestock in the provision of ecosystem services – examples from Poland	77
<b>1E1</b>	Yakutian cattle – a breed well adapted to subarctic climatic conditions	88
<b>1F1</b>	Production system changes as threats to animal genetic resources – a view from Africa	112
<b>1F2</b>	The potential impact of climate change on breed distribution – an example from Kenya	114
<b>1F3</b>	Animal genetic resources and access to grazing land – an example from India	115
<b>1F4</b>	Indiscriminate cross-breeding as a threat to animal genetic resources in Egypt	116
<b>1F5</b>	Lessons from history? Breed extinctions and near extinctions during the nineteenth century	118

<b>1F6</b>	The near extinction of the Cleveland Bay horse of the United Kingdom	119
<b>1F7</b>	The near extinction of the Lleyn sheep of the United Kingdom	119
<b>1F8</b>	Threats to animal genetic resources in Ethiopia	120
<b>1F9</b>	Threats to animal genetic resources in Mozambique	123
<b>1F10</b>	Shifting consumer demand as a threat to animal genetic resources – examples from around the world	123
<b>1F11</b>	Threats to animal genetic resources in the United States of America	124
<b>1F12</b>	Threats to animal genetic resources in Peru	124
<b>1F13</b>	Threats to animal genetic resources in Botswana	125
<b>1F14</b>	Effects of predation on sheep production in Norway	125
<b>1F15</b>	Projections for the risk of climatic disasters	130
<b>1F16</b>	The European Livestock Breeds Ark and Rescue Net	135

## **PART 2**

---

<b>2A1</b>	Demand for animal-source foods from minority species and breeds	165
<b>2A2</b>	Development of the poultry sector in Thailand	167
<b>2C1</b>	Efficiency and multifunctionality in extensive livestock systems	197
<b>2C2</b>	Shift of livestock species as a result of climate change: an example from Ethiopia	197
<b>2C3</b>	Animal genetic resources management in Iceland: will exotic breeds substitute locally adapted breeds?	200
<b>2C4</b>	The potential influence of genomics on the utilization of at-risk breeds	204

## **PART 3**

---

<b>3A1</b>	Strategic Priority Area 4 of the Global Plan of Action for Animal Genetic Resources	213
<b>3A2</b>	Elements of the recommended national institutional framework for the management of animal genetic resources	214
<b>3A3</b>	The role of the National Coordinator for the Management of Animal Genetic Resources	215
<b>3A4</b>	Facilitating the establishment of institutional frameworks for animal genetic resources management – lessons from a project in Bulgaria	229
<b>3A5</b>	FAO's role in the management of animal genetic resources	230
<b>3A6</b>	The Domestic Animal Diversity Network (DAD-Net)	231
<b>3A7</b>	Livestock Keepers' Rights	233
<b>3B1</b>	Characterization – definitions of terms	238
<b>3B2</b>	China's second national animal genetic resources survey	247
<b>3B3</b>	BushaLive – a collaborative project to characterize the Busha cattle of the Balkans	248
<b>3C1</b>	Sheep breeding in Tunisia	267
<b>3C2</b>	Kazakhstan's plan for the development of the beef-cattle industry	269

<b>3C3</b>	Using exotic genetics in the dairy sector – experiences from Poland	270
<b>3C4</b>	Beef cattle breeding in Brazil	272
<b>3C5</b>	Sheep breeding in Jordan	273
<b>3D1</b>	Implementing a conservation programme – experiences from China	290
<b>3D2</b>	Dyeing sheep wool naturally in 35 colours: indigenous production systems and associated traditional knowledge – a case from Argentina	291
<b>3D3</b>	The conservation network for the Finnish Landrace chicken	292
<b>3D4</b>	Iberian pigs in Spain – sustained through product labelling	293
<b>3D5</b>	Reconstituting a research pig line	301
<b>3D6</b>	Conservation of the Gembrong goat of Bali (Indonesia): a breed brought close to extinction by nylon fishing line	302
<b>3D7</b>	Switzerland’s virtual national gene bank – building on the work of the commercial sector	303
<b>3D8</b>	Development of the European Gene Bank Network for Animal Genetic Resources	305
<b>3E1</b>	Glossary: biotechnologies	309
<b>3E2</b>	Glossary: production systems	314
<b>3E3</b>	The use of reproductive technologies in South Africa	321
<b>3E4</b>	The use of reproductive technologies in Botswana	321
<b>3E5</b>	Artificial insemination in sheep and goats – an Indian experience	323
<b>3E6</b>	Biotechnologies for livestock production in Brazil – use and research	325
<b>3E7</b>	Use of biotechnologies in livestock production in the United States of America	326
<b>3F1</b>	Findings of a patent landscape report on animal genetic resources	338
<b>3F2</b>	Viet Nam’s legal framework for animal genetic resources management	364
<b>3F3</b>	Albania’s Law No. 9426 on Livestock Breeding	365
<b>3F4</b>	The Punjab Livestock Breeding Act 2014 (Pakistan)	366
<b>3F5</b>	The legal basis for Turkey’s animal genetic resources management programme	367
<b>3F6</b>	Official recognition of livestock breeds in Brazil	371
<b>3F7</b>	Registration of livestock breeds in Indonesia	372
<b>3F8</b>	The legal and policy framework for breeding programmes in Bhutan	376
<b>3F9</b>	The legal framework for the use of reproductive biotechnologies in Brazil	377
<b>3F10</b>	The legal basis for animal genetic resources conservation in Poland	381
<b>3F11</b>	The regulatory framework for the use of genetically modified organisms in Australia	385
<b>3F12</b>	Animal genetic resources management in Kenya’s National Livestock Policy	398

## PART 4

---

<b>4A1</b>	Phenotypic and molecular characterization	416
<b>4A2</b>	Elements of a country-based early warning and response system	417
<b>4A3</b>	Surveying and monitoring methods – a toolbox	421
<b>4A4</b>	A digital enumeration method for collecting phenotypic data for genome association	424
<b>4A5</b>	Biogeoinformatics for the management of animal genetic resources	426
<b>4A6</b>	Rumen microbes: small but significant	428
<b>4B1</b>	From DNA to phenotype	432
<b>4B2</b>	Glossary: genetic markers	434
<b>4B3</b>	How genetic tools helped to solve the mystery of the origin of the Booroola gene	438
<b>4B4</b>	What are the promises of the post-genomic era?	441
<b>4B5</b>	The reality and promises of epigenetics for animal production	442
<b>4C1</b>	Reduction of genetic variability and its consequences in cattle breeds	452
<b>4C2</b>	Genetically modified animals in agriculture	456
<b>4C3</b>	Adoption of genomic selection in French dairy sheep breeds	465
<b>4C4</b>	Improving the system of sheep breeding in Ireland	466
<b>4C5</b>	GENECOC – the breeding programme for meat goats and sheep in Brazil	478
<b>4C6</b>	Establishing a cross-breeding scheme for dairy goats in the United Republic of Tanzania	479
<b>4C7</b>	Community-driven breeding programmes for locally adapted pig breeds in Viet Nam	480
<b>4C8</b>	Genetic selection for reduced methane production – a future tool for climate change mitigation	484
<b>4D1</b>	Glossary: <i>in vivo</i> and <i>in vitro</i> conservation	497
<b>4D2</b>	Analysis of strengths, weaknesses, opportunities and threats (SWOT analysis) of Groningen White Headed cattle in the Netherlands	500
<b>4D3</b>	Biocultural community protocols	506
<b>4D4</b>	Identifying keys to success in breed conservation and development in France: the VARAPE project	510
<b>4D5</b>	Indigenous people and scientists team up to conserve Pantaneiro cattle in Brazil	512
<b>4D6</b>	A study of the comparative costs of <i>in vivo</i> and cryoconservation programmes for chickens	519
<b>4D7</b>	Use of induced pluripotent stem cells in <i>in vitro</i> conservation	520
<b>4D8</b>	Bilateral agreement on sanitary issues in germplasm exchange – an example	521
<b>4E1</b>	Biodiversity valuation, ecosystem services and animal genetic resources	533
<b>4E2</b>	Environmental valuation methods	534

## TABLES

<b>1</b>	Regional overview of country reporting	xxxiii
<b>2</b>	List of country reports	xxxiii

### **PART 1**

---

<b>1A1</b>	Domestication, dispersal and sources of introgression	8
<b>1A2</b>	Examples of genes or loci involved in selected traits	14
<b>1B1</b>	Status of information recorded in the Global Databank for Animal Genetic Resources	27
<b>1B2</b>	Number of reported mammalian local breeds	32
<b>1B3</b>	Number of reported avian local breeds	32
<b>1B4</b>	Number of reported mammalian transboundary breeds	33
<b>1B5</b>	Number of reported avian transboundary breeds	33
<b>1B6</b>	Number of extinct mammalian breeds reported	40
<b>1B7</b>	Number of extinct avian breeds reported	40
<b>1B8</b>	Breed extinction over time	41
<b>1C1</b>	Regional shares of germplasm exports and imports in the twenty-first century	48
<b>1D1</b>	Global output of animal-source foods (2004 and 2012)	67
<b>1E1</b>	Adaptations in cattle breeds as recorded in DAD-IS	84
<b>1E2</b>	Adaptations in sheep breeds as recorded in DAD-IS	84
<b>1E3</b>	Adaptations in equine breeds as recorded in DAD-IS	85
<b>1E4</b>	Examples of studies indicating breed differences in resistance, tolerance or immune response to specific diseases	91
<b>1E5</b>	Number of mammalian breed populations recorded in DAD-IS as having resistance or tolerance to specific diseases or parasites	92
<b>1E6</b>	Breeds recorded in DAD-IS as showing resistance or tolerance to trypanosomosis	93
<b>1E7</b>	Breeds recorded in DAD-IS as showing resistance or tolerance to tick burden	94
<b>1E8</b>	Breeds recorded in DAD-IS as showing resistance or tolerance to tick-borne diseases	94
<b>1E9</b>	Breeds recorded in DAD-IS as showing resistance or tolerance to internal parasites	95
<b>1E10</b>	Cattle breeds recorded in DAD-IS as showing resistance or tolerance to leukosis	96
<b>1E11</b>	Breeds recorded in DAD-IS as showing resistance or tolerance to foot rot	97
<b>1E12</b>	Avian breeds recorded in DAD-IS as showing resistance to diseases	99

<b>1F1</b>	Estimates of effective population size in transboundary breeds based on genealogical or molecular data	111
<b>1F2</b>	Factors reported in the country reports as causes of genetic erosion	122
<b>1G1</b>	Nutrient composition of selected animal-source foods	144
<b>1G2</b>	Selected nutrient composition ranges for milk from buffalo, horse and dromedary breeds	147
<b>1G3</b>	Selected nutrient composition ranges for beef (longissimus muscle) from different cattle breeds	148
<b>1G4</b>	Mineral content of milk from various species in relation to recommended nutrient intake	149

## **PART 2**

---

<b>2A1</b>	Previous and projected trends in meat consumption	158
<b>2A2</b>	Previous and projected trends in milk consumption	159
<b>2A3</b>	Growth in per capita demand for livestock products from 2000 to 2030	160
<b>2A4</b>	Direct and indirect effects of climate change on livestock production systems	168
<b>2A5</b>	Change in area of arable and pasture land (2000 to 2010)	169
<b>2A6</b>	A policy framework for inclusive growth of the livestock sector	173
<b>2B1</b>	Livestock production systems classification	179
<b>2C1</b>	Drivers of change explored in the country-report questionnaire	194
<b>2C2</b>	Past and predicted future impacts of livestock sector trends and drivers on animal genetic resources and their management	198

## **PART 3**

---

<b>3A1</b>	Reported extent of collaboration in the management of the various subsectors of genetic resources for food and agriculture	225
<b>3A2</b>	Organizations supporting animal genetic resources management at regional and international levels	232
<b>3A3</b>	Institutions and stakeholders – changes 2005 to 2014	234
<b>3B1</b>	Coverage of baseline surveys and monitoring programmes for the big five species	239
<b>3B2</b>	Coverage of baseline surveys and monitoring programmes for cattle	241
<b>3B3</b>	Coverage of baseline surveys and monitoring programmes for sheep, goats, pigs and chickens	242
<b>3B4</b>	Characterization activities for the big five species – average scores	245
<b>3C1</b>	Proportion of countries reporting the existence of breeding programmes – regional breakdown	252

<b>3C2</b>	Proportion of countries reporting the existence of breeding programmes – species breakdown	253
<b>3C3</b>	Extent of involvement of different stakeholder groups as operators of breeding programmes	254
<b>3C4</b>	Level of organization of livestock keepers with respect to animal breeding activities	261
<b>3C5</b>	Level of implementation of breeding-programme elements and techniques – regional breakdown	262
<b>3C6</b>	Level of implementation of breeding-programme elements and techniques – species breakdown	263
<b>3C7</b>	Proportion of breeds reported to be subject to breeding programmes applying straight/pure-breeding and cross-breeding	264
<b>3D1</b>	Proportion of countries reporting conservation activities	278
<b>3D2</b>	Breed coverage in conservation activities for the big five species – average scores	281
<b>3D3</b>	Proportion of countries reporting <i>in situ</i> conservation programmes	282
<b>3D4</b>	Proportion of countries reporting <i>ex situ in vivo</i> conservation programmes	283
<b>3D5</b>	Proportion of countries reporting <i>ex situ in vitro</i> conservation programmes	284
<b>3D6</b>	Level of breed coverage in conservation programmes for “minor” species	285
<b>3D7</b>	Proportion of countries reporting the use of elements of <i>in situ</i> conservation – species breakdown	287
<b>3D8</b>	Proportion of countries reporting the use of elements of <i>in situ</i> conservation – regional breakdown	288
<b>3D9</b>	Proportion of countries reporting the presence of <i>in vitro</i> gene banks, the storage of different types of genetic material, and plans for international collaboration in gene banking	296
<b>3D10</b>	Breed coverage of the big five species in gene banks	298
<b>3D11</b>	Breed coverage of “minor” species in gene banks	299
<b>3D12</b>	Characteristics and functions of national gene banks	300
<b>3E1</b>	Use of reproductive and molecular biotechnologies – regional breakdown	310
<b>3E2</b>	Use of advanced reproductive and molecular biotechnologies – regional breakdown	311
<b>3E3</b>	Level of availability of reproductive and molecular technologies for use in livestock production – big five species	312
<b>3E4</b>	Level of use of artificial insemination and sources of semen	315
<b>3E5</b>	Use of reproductive and molecular technologies – selected “minor” species	316
<b>3E6</b>	Stakeholder involvement in the provision of artificial insemination and embryo transfer services	318
<b>3E7</b>	Proportion of countries reporting research on reproductive biotechnologies	319
<b>3E8</b>	Proportion of countries reporting research on molecular biotechnologies	320
<b>3E9</b>	Changes in the level of use of reproductive biotechnologies since 2005	327



<b>3F1</b>	Priority levels of implementation of the strategic priorities of the Global Plan of Action for Animal Genetic Resources	331
<b>3F2</b>	Indicator scores for the implementation of the strategic priority areas of the Global Plan of Action for Animal Genetic Resources	332
<b>3F3</b>	Progress in the development of legal and policy frameworks	404

## **PART 4**

---

<b>4A1</b>	Usefulness of different surveying and monitoring tools to address different survey questions	423
<b>4B1</b>	Examples of non-disease phenotypes specific to one or more livestock breeds	439
<b>4C1</b>	Selection criteria in dairy cattle	461
<b>4C2</b>	Selection criteria in beef cattle	461
<b>4C3</b>	Recessive haplotypes tracked in the genomic evaluation system in the United States of America	462
<b>4C4</b>	Selection criteria in sheep	464
<b>4C5</b>	Selection criteria in goats	466
<b>4C6</b>	Selection criteria in pigs	468
<b>4C7</b>	Cross-breeding scheme and relative numbers in a typical broiler breeding programme	469
<b>4C8</b>	Selection criteria in poultry	471
<b>4C9</b>	Selection criteria in rabbits	473
<b>4C10</b>	Characteristics of conventional and community-based livestock breeding programmes	477
<b>4C11</b>	Selected community-based breeding programmes	477
<b>4D1</b>	Conservation methods and their potential to contribute to various objectives	499
<b>4D2</b>	Risk categories for species with high reproductive capacity	502
<b>4D3</b>	Risk categories for species with low reproductive capacity	502
<b>4D4</b>	Relative importance of population management objectives according to risk status	503
<b>4E1</b>	Overview of livestock breed and trait valuation studies by region (2006 to 2014)	535

## FIGURES

<b>1</b>	Assignment of countries to regions and subregions in this report	xxxv
----------	--	------

### PART 1

---

<b>1A1</b>	Three pathways of domestication	7
<b>1A2</b>	Major centres of livestock domestication as inferred from archaeological and molecular genetic evidence	10
<b>1B1</b>	Proportion of national breed populations for which population figures have been reported	28
<b>1B2</b>	Regional distribution of livestock species in 2012	29
<b>1B3</b>	Number of local and transboundary breeds at global level	31
<b>1B4</b>	Number of local and transboundary breeds at regional level	31
<b>1B5</b>	Proportion of the world's breeds by risk status category	35
<b>1B6</b>	Risk status of the world's mammalian breeds in June 2014 – species breakdown	36
<b>1B7</b>	Risk status of the world's avian breeds in June 2014 – species breakdown	37
<b>1B8</b>	Risk status of the world's mammalian breeds in June 2014 – regional breakdown	38
<b>1B9</b>	Risk status of the world's avian breeds June 2014 – regional breakdown	39
<b>1B10</b>	Changes in breed risk status between 2006 and 2014	41
<b>1C1</b>	Trends in the value of global exports of live animals and bovine semen	45
<b>1C2</b>	Do gene flows into and out of your country correspond to the pattern of North–North and/or North–South exchanges?	46
<b>1C3</b>	Trade in pig and bovine genetic resources between OECD and non-OECD countries (2005 to 2012)	47
<b>1C4</b>	Net exporters and importers of bovine semen (2006 to 2012)	49
<b>1C5</b>	South Africa's trade in live pure-bred cattle and bovine semen	56
<b>1C6</b>	Brazil's trade in live pure-bred cattle and bovine semen	57

### PART 2

---

<b>2A1</b>	Demand growth for poultry meat in China and India (2000 to 2030)	162
<b>2A2</b>	Net meat trade of major importer and exporter country groups	163
<b>2B1</b>	Distribution of livestock production systems	180
<b>2B2</b>	Production from the main livestock production systems	181
<b>2B3</b>	Meat production trends in developing and developed countries (1981 to 2050)	182
<b>2B4</b>	Proportion of pigs and poultry raised in intensive systems in 2005	183
<b>2B5</b>	Agricultural land available per person economically active in agriculture	188
<b>2C1</b>	Past and predicted future impacts of the drivers of change on animal genetic resources and their management	195

## PART 3

---

<b>3A1</b>	Submission of country reports and nomination of National Coordinators for the Management of Animal Genetic Resources	216
<b>3A2</b>	Employment affiliations of National Coordinators for the Management of Animal Genetic Resources	217
<b>3A3</b>	Status of National Advisory Committees for Animal Genetic Resources	217
<b>3A4</b>	Overview of the state of institutions in animal genetic resources management	218
<b>3A5</b>	State of institutions in animal genetic resources management – Africa	219
<b>3A6</b>	State of institutions in animal genetic resources management – Asia	219
<b>3A7</b>	State of institutions in animal genetic resources management – Latin America and the Caribbean	220
<b>3A8</b>	Indicators for the implementation of Strategic Priority Area 4 of the Global Plan of Action for Animal Genetic Resources	220
<b>3A9</b>	State of infrastructure and stakeholder participation	221
<b>3A10</b>	State of education, research and knowledge	221
<b>3A11</b>	State of policy development	222
<b>3B1</b>	Progress in the establishment of national breed inventories	240
<b>3B2</b>	Characterization activities for the big five species – frequency of responses	243
<b>3B3</b>	Characterization activities for “minor” species	244
<b>3C1</b>	Stakeholder involvement in breeding-related activities in ruminants and monogastrics – global averages	256
<b>3C2</b>	Involvement of breeders’ associations in breeding programmes and elements of breeding programmes	257
<b>3C3</b>	State of training in the field of animal breeding	258
<b>3C4</b>	State of implementation of training and technical support programmes for the breeding activities of livestock-keeping communities	259
<b>3C5</b>	State of research in the field of animal breeding	260
<b>3C6</b>	Proportion of countries reporting breeding programmes and policies supporting breeding programmes	266
<b>3C7</b>	Implementation of breeding tools in cattle (2005 and 2014)	275
<b>3D1</b>	Coverage of <i>in situ</i> conservation programmes for the big five livestock species	279
<b>3D2</b>	Breed coverage in conservation activities for the big five species – frequency of responses	280
<b>3D3</b>	Involvement of public and private institutions in the implementation of <i>in situ</i> conservation programme elements	294
<b>3D4</b>	State of development of <i>in vitro</i> gene banks for animal genetic resources	297
<b>3D5</b>	State of conservation programmes and policies at country level and progress since 2007	306

<b>3E1</b>	Level of availability of reproductive technologies	313
<b>3F1</b>	The status of national strategy and action plans for animal genetic resources	360
<b>3F2</b>	State of development of legal and policy instruments	362
<b>3F3</b>	Types of conservation targeted by legal and policy instruments	379
<b>3F4</b>	Inclusion of animal genetic resources issues in national biodiversity strategies and action plans	400

## **PART 4**

---

<b>4A1</b>	Management of breed populations – flow chart of decisions	418
<b>4A2</b>	Descriptor system for production environments	419
<b>4B1</b>	Change in cost per genome sequenced in humans	431
<b>4C1</b>	Structure of the poultry breeding industry	470
<b>4D1</b>	Interactions among the potential stakeholders of a community-based conservation programme	505
<b>4D2</b>	A decentralized <i>ex situ</i> conservation programme involving institutional herds and private breeders	507
<b>4E1</b>	Breed production functions, public-good values and replacement opportunity costs	532



# Foreword

**D**omesticated animals contribute directly to the livelihoods of millions of people, including an estimated 70 percent of the world's rural poor. In 2007, through the adoption of the Global Plan of Action for Animal Genetic Resources, the international community recognized the vital importance of the world's livestock biodiversity for agriculture, rural development and food and nutrition security.

Eight years later, the conservation and sustainable management of animal genetic resources remains a vital and challenging task. The global livestock sector is continuously evolving, with new centres of growth emerging and rapid technological developments. The challenges posed by population growth and climate change are ever more present.

*The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture* – another milestone in the work of FAO's Commission on Genetic Resources for Food and Agriculture – provides a comprehensive and updated assessment of current livestock biodiversity. It draws on information provided by 129 countries, 15 international organizations, 4 networks and regional focal points and inputs from 150 authors and reviewers.

The preparation of *The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture* offered an opportunity to review progress made in the implementation of the Global Plan of Action. It was a chance to re-evaluate the opportunities and challenges facing national authorities, livestock keepers, breeders and scientists and to identify future priorities for action.

Many countries have made progress in the establishment of the policies, programmes and institutional frameworks needed to promote the sustainable management of livestock diversity. Many weaknesses still need to be addressed, particularly in developing countries. Smallholder and pastoralist production systems that are home to much of the world's livestock diversity continue to be under a range of pressures.

A substantial proportion of the world's livestock breeds remain at risk of extinction. The characteristics of many of them have not been adequately studied, and this genetic wealth could be lost before it can be used for helping farmers, pastoralists and animal breeders to meet current and future production challenges.

Knowledge gaps are still a major concern. Monitoring of trends in the size and structure of breed populations is often inadequate, which impedes the estimation of risk status. Threats have been broadly identified, but the detailed information that could be used to prioritize and plan action at the national level is often lacking.

The priorities set out in the Global Plan of Action for Animal Genetic Resources remain broadly relevant today. Many countries have prepared national strategies and action plans for animal genetic resources, or are in the process of doing so, as a means to translate the provisions of the Global Plan of Action into targeted activities at country level. Nevertheless, constraints to implementation remain. The Global Plan of Action emphasizes the importance of international collaboration as a means of

strengthening capacity in developing countries, and recognizes the need for substantial additional financial resources for animal genetic resource management. While there have been positive developments, both collaboration and the provision of funding still need to be strengthened.

Genetic diversity is a mainstay of resilience and a prerequisite for adaptation in the face of future challenges. I trust that this report will help underpin renewed efforts to ensure that animal genetic resources are used and developed to promote global food security, and remain available for future generations.



**José Graziano da Silva**  
FAO Director-General

# Acknowledgements

This report could not have been prepared without the assistance of the many individuals who generously contributed their time, energy and expertise, and the collaboration and support of governments. FAO would like to take this opportunity to acknowledge these contributions.

The core of the information used in the preparation of *The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture* was provided by the 129 governments that submitted country reports; the first and most important acknowledgement therefore goes to these governments and to all the individuals at country level who contributed to these reports and to the updating of breed-related data in the Domestic Animal Diversity Information System (DAD-IS), in particular National Coordinators for the Management of Animal Genetic Resources and their colleagues. The African Union – Interafrican Bureau for Animal Resources (AU-IBAR) was instrumental in mobilizing African National Coordinators and supported their training in the preparation of country reports. Thanks are also due to everyone who contributed to the preparation of the reports submitted by international organizations and regional focal points and networks for animal genetic resources. The preparation of the report would not have been possible without the financial and in-kind support provided by the Governments of France, Germany, Norway and Spain.

The report was prepared by FAO's Animal Genetic Resources Branch, Animal Production and Health Division. The reporting process and the preparation of the report were coordinated by Beate Scherf with the assistance of Dafydd Pilling. The work was facilitated and supported by the Chief of Animal Genetic Resources Branch, Irene Hoffmann, and all officers of the Branch: Roswitha Baumung, Badi Besbes, Paul Boettcher, Mateusz Wiczorek and Grégoire Leroy (seconded by the French Government). The work was further supported by a number of interns: Bendik Elstad (Norway), Tatiana From (Russian Federation), Katherine Hall (United Kingdom), Claire-Marie Luitaud (France) and Jessica Miller (United States of America).

The database of country-report data was designed, created, loaded and pre-analysed by a team from FAO's Information Technology Division led by Gianluca Franceschini and Karl Morteo. Daniel Martin-Collado undertook much of the database analysis for Part 3 of the report. Peter Deupmann of FAO's Legal Office provided support to the organization of the survey on legal and policy measures and related work. David Steane contributed to the reviewing of draft country reports. Oliver Mundy contributed to the communication strategy for the launch of the report. Administrative and secretarial support was provided by Kafia Fassi-Fihri and Umberto Ciniglio.

Throughout the preparation process, support and encouragement were received from the Secretariat of the Commission on Genetic Resources for Food and Agriculture, as well as from the Director of FAO's Animal Production and Health Division, Berhe G. Tekola.

150 individuals from more than 40 countries contributed to the preparation of the report as authors or reviewers. Details are provided below, section by section. An alphabetical list of authors and reviewers and their contact details is provided in the annex to the report (on CD-ROM and at <http://www.fao.org/3/a-i4787e/i4787e195.pdf>).



## **Authors and reviewers<sup>1</sup>**

### **Part 1 THE STATE OF LIVESTOCK DIVERSITY**

#### **Section A: Origin and history of livestock diversity**

*Author:* Johannes Lenstra

*Reviewers:* Gus Cothran, Charles Moses Liymo, Steffen Weigend, Pam Wiener

#### **Section B: Status and trends of animal genetic resources**

*Authors:* Roswitha Baumung, Mateusz Wieczorek

*Reviewer:* Mary Mbole-Kariuki

#### **Section C: Flows of animal genetic resources**

*Authors:* Claire-Marie Luitaud, Dafydd Pilling

*Reviewers:* Arthur Da Silva Mariante, Keith Ramsay

#### **Section D: Roles, uses and values of animal genetic resources**

*Author:* Dafydd Pilling

*Reviewers:* Ilse Köhler-Rollefson, Chanda Bonbehari Nimbkar

#### **Section E: Animal genetic resources and adaptation**

*Authors:* Paul Boettcher, Aynalem Haile, Katherine Hall, Jessica Louise Miller, Tadele Mirkena, Beate Scherf, Maria Wurzinger

*Reviewers (Subsection 4):* Donagh Berry, Stephen Bishop, Larry Kuehn, Marie-Hélène Pinard-van der Laan

#### **Section F: Threats to livestock genetic diversity**

*Author:* Dafydd Pilling

*Reviewers:* Kefyalew Alemayehu, Siboniso Moyo

#### **Section G: Livestock diversity and human nutrition**

*Author:* Doris Rittenschober

*Reviewers:* Ruth Charrondiere, Dominique Gruffat, Jean-François Hocquette, Ramani Wijesinha-Bettoni

### **Part 2 LIVESTOCK SECTOR TRENDS**

#### **Section A: Drivers of change in the livestock sector**

*Authors:* Claire-Marie Luitaud, Anni McLeod

#### **Section B: The livestock sector's response**

*Authors:* Claire-Marie Luitaud, Anni McLeod

#### **Section C: Effects of changes in the livestock sector on animal genetic resources and their management**

*Authors:* Grégoire Leroy, Claire-Marie Luitaud, Dafydd Pilling

#### **Section D: Livestock sector trends and animal genetic resources management – conclusions**

*Author:* Dafydd Pilling

*Reviewers of Part 2:* Alejandro Acosta, Harinder Makkar

### **Part 3 THE STATE OF CAPACITIES**

#### **Section A: Institutions and stakeholders**

*Authors:* Katherine Hall, Dafydd Pilling

*Reviewers:* Vera Matlova, Joseph L.N. Sikosana

---

<sup>1</sup> Listed in alphabetical order within each section.

**Section B: Characterization, inventory and monitoring**

*Author:* Daniel Martin-Collado, Dafydd Pilling

*Reviewers:* Workneh Ayalew, Kathiravan Periasamy, Michèle Tixier-Boichard

**Section C: Breeding programmes**

*Author:* Daniel Martin-Collado

*Reviewers:* Vlatka Cubric Curik, Olaf Thieme

**Section D: Conservation programmes**

*Author:* Daniel Martin-Collado

*Reviewer:* Kor Oldenbroek

**Section E: Reproductive and molecular biotechnologies**

*Author:* Daniel Martin-Collado

*Reviewer:* Oswin Perera

**Section F: Legal and policy frameworks**

*Authors:* Dafydd Pilling, with contributions from Bendik Elstad, Dan Leskien, Irene Kitsara, Brittny Martin and Elżbieta Martyniuk

*Reviewers:* Harvey Blackburn, Olivier Diana, Dan Leskien, Oliver Lewis, Sipke Joost Hiemstra, Gigi Manicad, Arthur da Silva Mariante, Sergio Pavon

**Part 4 THE STATE OF THE ART****Section A: Surveying, monitoring and characterization**

*Authors:* Paul Boettcher, Beate Scherf,

*Reviewers:* Workneh Ayalew, Xavier Rognon

**Section B: Molecular tools for exploring genetic diversity**

*Authors:* Mike Bruford, Grégoire Leroy, Pablo Orozco-terWengel, Andrea Rau, Henner Simianer

*Reviewers:* Bertrand Bed'Hom, Christine Flury, Catarina Ginja, Johannes Lenstra, Michael Stear

**Section C: Breeding strategies and programmes**

*Authors:* Peter Amer, Daniel Allain, Santiago Avendano, Manuel Baselga, Paul Boettcher, João Dürr, Hervé Garreau, Elisha Gootwine, Gustavo Gutierrez, Pieter Knap, Eduardo Manfredi, Victor Olori, Rudolf Preisinger, Juan Manuel Serradilla, Miriam Piles, Bruno Santos, Kenneth Stalder

*Reviewers:* Hélène Larroque, Tadele Mirkena, Joaquin Pablo Mueller, Julie M.F. Ojango, Mauricio Valencia Posadas

**Section D: Conservation**

*Authors:* Harvey Blackburn, Paul Boettcher, Kor Oldenbroek

*Reviewers:* Andréa Alves do Egito, Jesús Fernández Martín, Sipke Joost Hiemstra, Samuel Rezende Paiva, Geoff Simm

**Section E: Economics of animal genetic resources use and conservation**

*Authors:* Workneh Ayalew, Adam Drucker, Kerstin Zander

*Reviewer:* Giovanni Signorello

**Part 5 NEEDS AND CHALLENGES**

*Author:* Beate Scherf

The manuscript was further reviewed by Stuart Barker (Parts 1 and 2), David Notter (Parts 1, 2, 4 and 5), David Steane and Akke J. Van der Zijpp (Parts 1, 2 and 5). All the officers of FAO's Animal Genetic Resources Branch also contributed to the reviewing process.

Text boxes were prepared by Aron Batubara, Harvey Blackburn, Elli Broxham, Tobias Bühlmann, Adrian Cookson, Christèle Couzy, Yvette De Haas, Sebastián de la Rosa, Solange Duruz, Gemma Henderson, Sipke Joost Hiemstra, Erika Hiltbrunner, Mervi Honkatukia, Heather J. Huson, Peter Janssen, Stéphane Joost, Talgat Karymsakov, Bill Kelly, Sajjad Khan, Jason K. Kinser, Eirini Kitsara, Ilse Köhler-Rollefson, Christian Körner, Kristaq Kume, Sinead Leahy, Johannes Lenstra, I Made Londra, Catherine Marguerat, Arthur Da Silva Mariente, Lucie Markey, Elżbieta Martyniuk, Evelyn Mathias, Yakobo Msanga, Philipp Muth, Chanda Bonbehari Nimbkar, Raimundo Nonato Braga Lôbo, Cleopas Okore, Bertrand Pain, Boulbaba Rekik, Fred Silversides, Tad S. Sonstegard, Johann (Hans) Sölkner, Sylvie Stucki, Thi Thuy Le, Bess Tiesnamurti, Sergio Ulhoa Dani, Anne Valle Zárate, Curtis P. Van Tassell, Iosif I. Vaisman, Marcus Vinicius de Oliveira, Klaus Wimmers, Jennifer Woodward-Greene, Hongjie Yang and Tobias Zehnder.

The thematic study *Ecosystem services provided by livestock species and breeds with special consideration to the contributions of small-scale livestock keepers and pastoralists* was prepared by Irene Hoffmann, Tatiana From and David Boerma. The study *Patent landscape report on animal genetic resources* was prepared by Paul Oldham, Stephen Hall and Colin Barnes, with contributions from Irene Hoffmann and Paul Boettcher.

The draft report was made available for review by members and observers of the Commission on Genetic Resources for Food and Agriculture. Comments, submitted by the respective National Coordinators for the Management of Animal Genetic Resources, were received from the Governments of Brazil, Indonesia, Mongolia, the Netherlands, Slovakia, Turkey and the United States of America and from a review group established by the European Regional Focal Point for Animal Genetic Resources.

The layout was designed by Simona Capocaccia and implemented by Enrico Masci under the supervision of Claudia Ciarlantini.

Listing every person by name is not easy and carries with it the risk that someone may be overlooked. Apologies are conveyed to anyone who provided assistance but whose name has been omitted.

# Abbreviations and acronyms

<b>AI</b>	artificial insemination
<b>AnGR</b>	animal genetic resources for food and agriculture
<b>BLUP</b>	best linear unbiased prediction
<b>CBD</b>	Convention on Biological Diversity ( <a href="https://www.cbd.int">https://www.cbd.int</a> )
<b>CGIAR</b>	Consultative Group on International Agricultural Research ( <a href="http://www.cgiar.org">http://www.cgiar.org</a> )
<b>CGRFA</b>	Commission on Genetic Resources for Food and Agriculture ( <a href="http://www.fao.org/nr/cgrfa">http://www.fao.org/nr/cgrfa</a> )
<b>DAD-IS</b>	Domestic Animal Diversity Information System ( <a href="http://www.fao.org/dad-is">http://www.fao.org/dad-is</a> )
<b>DNA</b>	deoxyribonucleic acid
<b>EBV</b>	estimated breeding value
<b>EU</b>	European Union ( <a href="http://europa.eu">http://europa.eu</a> )
<b>GEBV</b>	genomic estimated breeding value
<b>ICAR</b>	International Committee for Animal Recording ( <a href="http://www.icar.org">http://www.icar.org</a> )
<b>MAS</b>	marker-assisted selection
<b>MOET</b>	multiple ovulation and embryo transfer
<b>OIE</b>	World Organisation for Animal Health (Office International des Epizooties) ( <a href="http://www.oie.int">http://www.oie.int</a> )
<b>QTL</b>	quantitative trait locus
<b>SNP</b>	single nucleotide polymorphism
<b>TEV</b>	total economic value
<b>WIPO</b>	World Intellectual Property Organization ( <a href="http://www.wipo.int">http://www.wipo.int</a> )
<b>WTO</b>	World Trade Organization ( <a href="http://www.wto.org">http://www.wto.org</a> )
<b>First SoW-AnGR</b>	(first report on) <i>The State of the World's Animal Genetic Resources for Food and Agriculture</i>
<b>Second SoW-AnGR</b>	<i>The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture</i>



# About this publication

## Background

This report serves as an update of the first report on *The State of the World's Animal Genetic Resources for Food and Agriculture* (first SoW-AnGR) (see Box 1), published in 2007,<sup>1</sup> which provided the basis for the development of the Global Plan of Action for Animal Genetic Resources,<sup>2</sup> adopted in 2007 as the first internationally agreed framework specifically targeting the management of livestock biodiversity.

### Box 1

#### **The first report on *The State of the World's Animal Genetic Resources for Food and Agriculture* (2007)**

*The State of the World's Animal Genetic Resources for Food and Agriculture*,<sup>1</sup> the first comprehensive global assessment of livestock biodiversity and its management, was published by FAO in 2007. The report was the outcome of an extensive reporting and preparatory process initiated by the Commission on Genetic Resources for Food and Agriculture in 1999. In March 2001, FAO invited 188 countries to submit country reports on their animal genetic resources. The intention was that the preparation of these reports (in addition to providing the basis for a global assessment) would help countries to identify national priorities for action in the sustainable use, development and conservation of animal genetic resources. While countries were provided with guidelines and a proposed structure for their reports, the process was not based on a standardized questionnaire.

Between 2002 and 2005, FAO received 169 country reports. These were complemented by 9 reports from international organizations<sup>2</sup> and 12 thematic studies<sup>3</sup> commissioned to address specific aspects of animal genetic resources management. More than 90 authors and reviewers were involved in the preparation of the main report. The country reports, reports from

international organizations and thematic studies, along with subregional and regional reports on animal genetic resources, were provided on the CD-ROM that accompanied the report. This material is also all available on the web site of FAO's Animal Production and Health Division.<sup>4</sup>

The report was published in seven languages and an "in brief" version in more than ten languages. The report was launched at the first International Technical Conference on Animal Genetic Resources for Food and Agriculture,<sup>5</sup> held in Interlaken, Switzerland, in September 2007. The conference also adopted the Global Plan of Action for Animal Genetic Resources and the Interlaken Declaration on Animal Genetic Resources.

<sup>1</sup> FAO. 2007a. *The State of the World's Animal Genetic Resources for Food and Agriculture*, edited by B. Rischkowsky & D. Pilling. Rome (available at [www.fao.org/3/a-a1250e.pdf](http://www.fao.org/3/a-a1250e.pdf)).

<sup>2</sup> [ftp://ftp.fao.org/docrep/fao/010/a1250e/annexes/Reports from International Organizations/IntOrganisationReports.pdf](http://ftp.fao.org/docrep/fao/010/a1250e/annexes/Reports%20from%20International%20Organizations/IntOrganisationReports.pdf)

<sup>3</sup> [ftp://ftp.fao.org/docrep/fao/010/a1250e/annexes/Thematic Studies/ThematicStudies.pdf](http://ftp.fao.org/docrep/fao/010/a1250e/annexes/Thematic%20Studies/ThematicStudies.pdf)

<sup>4</sup> [http://www.fao.org/ag/againfo/programmes/en/genetics/first\\_state.html](http://www.fao.org/ag/againfo/programmes/en/genetics/first_state.html)

<sup>5</sup> <http://www.fao.org/ag/againfo/programmes/en/genetics/angrvent2007.html>

<sup>1</sup> FAO. 2007a. *The State of the World's Animal Genetic Resources for Food and Agriculture*, edited by B. Rischkowsky & D. Pilling. Rome (available at [www.fao.org/3/a-a1250e.pdf](http://www.fao.org/3/a-a1250e.pdf)).

<sup>2</sup> FAO. 2007b. *The Global Plan of Action for Animal Genetic Resources and the Interlaken Declaration*. Rome (available at <http://www.fao.org/docrep/010/a1404e/a1404e00.htm>).

## Box 2

### The Commission on Genetic Resources for Food and Agriculture

With its 178 member countries, the Commission on Genetic Resources for Food and Agriculture offers an intergovernmental forum where global consensus can be reached on policies relevant to biodiversity for food and agriculture. The main objective of the Commission is to ensure the conservation and sustainable use of genetic resources for food and agriculture and the fair and equitable sharing of benefits derived from their use, for present and future generations. Its work focuses on developing and overseeing

the implementation of policies and supporting initiatives that raise awareness and seek to solve emerging problems. It guides the preparation of periodic global assessments of the status and trends of genetic diversity, the threats facing genetic diversity and the measures being taken to promote its conservation and sustainable use. The Commission also negotiates global action plans, codes of conduct and other instruments relevant to the conservation and sustainable use of genetic resources for food and agriculture.

FAO's reports on the state of the world's genetic resources are prepared under the guidance of the Commission on Genetic Resources for Food and Agriculture<sup>3</sup> (see Box 2). To date, in addition to the first SoW-AnGR, two reports have been published on plant genetic resources for food and agriculture (1998 and 2010)<sup>4</sup> and one on forest genetic resources (2014).<sup>5</sup>

### Scope and contents of the report

This report addresses the sustainable use, development and conservation of animal genetic resources for food and agriculture (AnGR) worldwide. The term AnGR here refers to the genetic resources of mammalian and avian species used or potentially used for food and agriculture. The report consists of the following five parts.

**Part 1** provides a broad overview of livestock diversity, including the origins and history of AnGR, the status and trends of AnGR (the state of genetic diversity as indicated by the risk status of breed populations), the state of gene flows (movements of AnGR around the world), the uses, roles and values of AnGR, the adaptedness of AnGR to environmental stressors, threats to AnGR, and the influence of genetic diversity on the composition of animal-source food products.

**Part 2** discusses livestock-sector trends and how they are affecting AnGR and their management.

**Part 3** discusses the state of capacity to manage AnGR, including institutional frameworks, programmes for inventory, characterization and monitoring, breeding strategies and programmes, conservation programmes, the use of reproductive and molecular biotechnologies, and legal and policy frameworks.

**Part 4** discusses the "state of the art" in the management of AnGR, including methods, tools and strategies used in inventory, characterization and monitoring, breeding programmes, conservation programmes and economic valuation of AnGR.

**Part 5** draws on the material presented in the other parts of the report to provide an assessment of gaps and needs in the management of AnGR and how they can be addressed.

<sup>3</sup> <http://www.fao.org/nr/cgrfa/en/>

<sup>4</sup> FAO. 1998. *The State of the World's Plant Genetic Resources for Food and Agriculture*. Rome (<http://www.fao.org/agriculture/crops/core-themes/theme/seeds-pgr/sow/en/>); FAO. 2010. *The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture*. Rome (<http://www.fao.org/docrep/013/i1500e/i1500e00.htm>).

<sup>5</sup> FAO 2014. *The State of the World's Forest Genetic Resources*. Rome (available at <http://www.fao.org/forestry/fgr/64582/en/>).

The report serves as basis for a review and potential update of the Global Plan of Action for Animal Genetic Resources.

## The reporting and preparatory process

In April 2013, the Commission on Genetic Resources for Food and Agriculture requested FAO to coordinate the preparation of *The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture* (second SoW-AnGR), focusing particularly on changes that had occurred since the preparation of the first SoW-AnGR.<sup>6</sup>

The first draft of the report was prepared between January and October 2014. In November 2014, it was submitted to the Eighth Session of the Intergovernmental Technical Working Group on Animal Genetic Resources for Food and Agriculture (a subsidiary body of the Commission charged with addressing issues relevant to the management of animal genetic resources)<sup>7</sup> for review. The first draft included Parts 1, 2, 3 and 5 of the report. At the request of the Fifteenth Regular Session of the Commission (January 2015), a revised draft, including all five parts, was made available for comments by members and observers of the Commission in May 2015. The report was finalized, taking comments received into account.

## Inputs to the report

The main sources used to prepare the second SoW-AnGR were as follows:

### Country reports

In August 2013, FAO invited its 191 member nations, as well as non-member nations, to submit country reports on the management of their AnGR, using a standardized electronic questionnaire<sup>8</sup> that had been endorsed by the Commission and finalized by the Bureau<sup>9</sup> of the Intergovernmental Technical Working Group on Animal Genetic Resources for Food and Agriculture. Government-appointed National Coordinators for the Management of Animal Genetic Resources led the preparation of the reports in their respective countries.

The country-report questionnaire<sup>10</sup> consisted of four sections:

- I. Executive summary
- II. Data for updating the parts and sections of *The State of the World's Animal Genetic Resources for Food and Agriculture*
  - Flows of animal genetic resources
  - Livestock sector trends
  - Overview of animal genetic resources
  - Characterization
  - Institutions and stakeholders
  - Breeding programmes
  - Conservation
  - Reproductive and molecular biotechnologies

---

<sup>6</sup> CGRFA-14/13/Report, paragraph 71 (<http://www.fao.org/docrep/meeting/028/mg538e.pdf>).

<sup>7</sup> <http://www.fao.org/ag/againfo/programmes/en/genetics/angrvent-1st-docs.html>

<sup>8</sup> [http://www.fao.org/Ag/AGInfo/programmes/en/genetics/Second\\_state.html](http://www.fao.org/Ag/AGInfo/programmes/en/genetics/Second_state.html)

<sup>9</sup> <http://www.fao.org/Ag/AGInfo/programmes/en/genetics/angrvent-bureau.html>

<sup>10</sup> [http://www.fao.org/ag/againfo/programmes/en/genetics/documents/SoW2\\_CR\\_E.pdf](http://www.fao.org/ag/againfo/programmes/en/genetics/documents/SoW2_CR_E.pdf)



- III. Data contributing to the preparation of *The State of the World's Biodiversity for Food and Agriculture*<sup>11</sup>
  - Integration of the management of animal genetic resources with the management of plant, forest and aquatic genetic resources
  - Animal genetic resources management and the provision of regulating and supporting ecosystem services
- IV. Progress report on the implementation of the Global Plan of Action for Animal Genetic Resources – 2007 to 2013<sup>12</sup>
  - Strategic Priority Area 1: Characterization, Inventory and Monitoring of Trends and Associated Risks
  - Strategic Priority Area 2: Sustainable Use and Development
  - Strategic Priority Area 3: Conservation
  - Strategic Priority Area 4: Policies, Institutions and Capacity-building
  - Implementation and financing of the Global Plan of Action for Animal Genetic Resources

Country reports were received between 31 January 2014 and 22 May 2014. Comments on the completeness and internal consistency of the reports were provided to National Coordinators. Based on these comments, final versions of the country reports were submitted. The data provided in the country reports were loaded into a database for analysis.

One hundred and twenty-eight country reports<sup>13</sup> were received in the standardized format – 30 from OECD countries (88 percent of OECD countries) and 98 from non-OECD countries (61 percent of non-OECD countries). The regional breakdown of the reporting is summarized in the Table 1. The full list of reporting countries is shown in Table 2.

### ***Survey responses on policy and legal frameworks***

Detailed questions on national-level legal and policy frameworks affecting the management of AnGR were not included in the country-report questionnaire. In order to enable the respective section of the report (Part 3 Section F) to be updated, FAO conducted a separate survey on this issue. In September 2013, National Coordinators for the Management of Animal Genetic Resources were requested to complete an electronic questionnaire<sup>14</sup> on the legal and policy frameworks in their respective countries. The following 46 countries provided responses: Australia, Austria, Bhutan, Brazil, Bulgaria, Burundi, Costa Rica, Croatia, Cyprus, the Czech Republic, the Democratic Republic of the Congo, Ecuador, Ethiopia, Finland, France, Germany, Ghana, Guatemala, Hungary, Iraq, Italy, Jordan, Latvia, Luxembourg, Malaysia, Mauritius, Montenegro, Namibia, Nepal, the Netherlands, Norway, the Republic of Korea, Serbia, Slovenia, Spain, Sri Lanka, Sudan, Suriname, Sweden, Switzerland, the United Republic of Tanzania, Thailand, the United States of America, Uruguay, Viet Nam and Zimbabwe.<sup>15</sup>

<sup>11</sup> In 2013, the Commission requested FAO to prepare *The State of the World's Biodiversity for Food and Agriculture*, a report focusing on interactions between the different subsectors of genetic resources for food and agriculture and on cross-sectoral matters (CGRFA-14/13/Report) (<http://www.fao.org/docrep/meeting/028/mg538e.pdf>).

<sup>12</sup> In 2009, the Commission agreed to a timetable and format for reporting on progress made in the implementation of the Global Plan of Action for Animal Genetic Resources at national level (CGRFA-12/09/Report) (<ftp://ftp.fao.org/docrep/fao/meeting/017/k6536e.pdf>). The first round of reporting took place in 2012 (CGRFA/WG-AnGR-7/12/Inf.3) (<http://www.fao.org/docrep/meeting/026/me636e.pdf>). A second round of reporting was incorporated into the country-reporting process for the second SoW-AnGR.

<sup>13</sup> <http://www.fao.org/3/a-i4787e/i4787e01.htm>

<sup>14</sup> [http://www.fao.org/Ag/AGInfo/programmes/en/genetics/Second\\_state.html](http://www.fao.org/Ag/AGInfo/programmes/en/genetics/Second_state.html)

<sup>15</sup> <http://www.fao.org/3/a-i4787e/i4787e02.htm>

TABLE 1

**Regional overview of country reporting**

Region	Number of countries in the region*	Number of country reports (second SoW-AnGR)	Number of country reports (first SoW-AnGR)	Coverage (second SoW-AnGR) (%)
Africa	52	41	49	79
Asia	31	20	26	65
Europe and the Caucasus	49	35	41	71
Latin America and the Caribbean	33	18	30	55
Near and Middle East	14	7	9	50
North America	2	1	2	50
Southwest Pacific	15	7	12	47
<b>Total</b>	<b>196</b>	<b>129</b>	<b>169</b>	<b>66</b>

\*The number of countries refers to the number of countries in 2014. Between 2005 (when the country reporting for the first SoW-AnGR was completed) and 2014, Montenegro and Serbia and South Sudan and Sudan became separate countries. For the purposes of the first SoW-AnGR, Sudan was part of the Near and Middle East region. For the purposes of the second SoW-AnGR, Sudan is part of the Near and Middle East region and South Sudan is part of the Africa region.

TABLE 2

**List of country reports**

Region <sup>1</sup>	Countries
Africa (41)	Algeria, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Comoros, Côte d'Ivoire, Democratic Republic of the Congo, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, <sup>2</sup> Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Swaziland, Togo, Uganda, United Republic of Tanzania, Zambia, Zimbabwe
Asia (20)	Bangladesh, Bhutan, China, India, Indonesia, Iran (Islamic Republic of), Japan, Kazakhstan, Kyrgyzstan, Malaysia, Maldives, Mongolia, Nepal, Philippines, Republic of Korea, Sri Lanka, Tajikistan, Thailand, Timor-Leste, Viet Nam
Europe and the Caucasus (35)	Albania, Austria, Azerbaijan, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Latvia, Lithuania, Luxembourg, Montenegro, Netherlands, Norway, Poland, Portugal, Russian Federation, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom
Latin America and the Caribbean (18)	Argentina, Barbados, Bolivia (Plurinational State of), Brazil, Chile, Costa Rica, Cuba, Dominican Republic, Ecuador, Guatemala, Jamaica, Mexico, Paraguay, Peru, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay
Near and Middle East (7)	Bahrain, Egypt, Iraq, Jordan, Kuwait, Oman, Sudan
North America (1)	United States of America
Southwest Pacific (7)	Cook Islands, Kiribati, New Zealand, Niue, Samoa, Solomon Islands, Tonga

<sup>1</sup> Note that these regions do not correspond to the usual FAO regions; see below for further explanation.

<sup>2</sup> The country report was not prepared in the standardized format and thus could not be included in the quantitative analysis.

### **Reports from regional focal points and networks**

In February 2014, regional focal points and networks for the management of AnGR were invited to provide reports (based on a standardized electronic questionnaire)<sup>16</sup> on activities related to the implementation of the Global Plan of Action in their respective regions. In accordance with the reporting framework agreed by the Commission, the regional focal points and networks were requested to highlight collaborative efforts at regional level and indicate regional priorities for capacity-building in relation to the implementation of the Global Plan of Action, rather than to provide a summary of national-level activities in the region. Reports<sup>17</sup> were received from the following regional focal points and networks:

1. the European Regional Focal Point for Animal Genetic Resources;
2. the Regional Focal Point for Latin America and the Caribbean;
3. the Animal Genetic Resources Network – Southwest Pacific; and
4. the Asian Animal Genetic Resources Network.

### **Reports from international organizations**

In February 2014, 209 international organizations were invited to report (based on a standardized electronic questionnaire)<sup>18</sup> on their contributions to the implementation of the Global Plan of Action for Animal Genetic Resources, in particular on any activities, programmes or projects undertaken or supported by the respective organization. Reports<sup>19</sup> were received from the following fifteen organizations: the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD); the African Union – Interafrican Bureau for Animal Resources (AU-IBAR); Bioersity International; the Secretariat of the Convention on Biological Diversity (CBD); the European Federation of Animal Science (EAAP); Heifer International; the International Atomic Energy Agency (IAEA); the International Committee for Animal Recording (ICAR); the International Center for Agriculture Research in the Dry Areas (ICARDA); the International Livestock Research Institute (ILRI); the League for Pastoral Peoples and Endogenous Livestock Development (LPP); the Nordic Genetic Resource Centre (NordGen); Rare Breeds International (RBI); Safeguard for Agricultural Varieties in Europe (SAVE Foundation); and the World Intellectual Property Organization (WIPO).

### **Thematic studies**

Two thematic studies providing in-depth analysis of specific topics relevant to the management of AnGR were prepared as part of the second SoW-AnGR reporting process:

- *Ecosystem services provided by livestock species and breeds, with special consideration to the contributions of small-scale livestock keepers and pastoralists;*<sup>20</sup>
- *The patent landscape for animal genetic resources.*<sup>21</sup>

### **Other sources**

In addition to the sources mentioned above, the second SoW-AnGR draws on a range of literature and data sources. The latter include the Domestic Animal Diversity Information System (DAD-IS),<sup>22</sup> FAO's legal database FAOLEX,<sup>23</sup> FAO's statistical database FAOSTAT,<sup>24</sup> the

---

<sup>16</sup> [http://www.fao.org/Ag/AGAInfo/programmes/en/genetics/Second\\_state.html](http://www.fao.org/Ag/AGAInfo/programmes/en/genetics/Second_state.html)

<sup>17</sup> <http://www.fao.org/3/a-i4787e/4787e03.htm>

<sup>18</sup> [http://www.fao.org/Ag/AGAInfo/programmes/en/genetics/Second\\_state.html](http://www.fao.org/Ag/AGAInfo/programmes/en/genetics/Second_state.html)

<sup>19</sup> <http://www.fao.org/3/a-i4787e/4787e03.htm>

<sup>20</sup> <http://www.fao.org/3/a-at598e.pdf>

<sup>21</sup> [http://www.wipo.int/edocs/pubdocs/en/wipo\\_pub\\_947\\_3.pdf](http://www.wipo.int/edocs/pubdocs/en/wipo_pub_947_3.pdf)

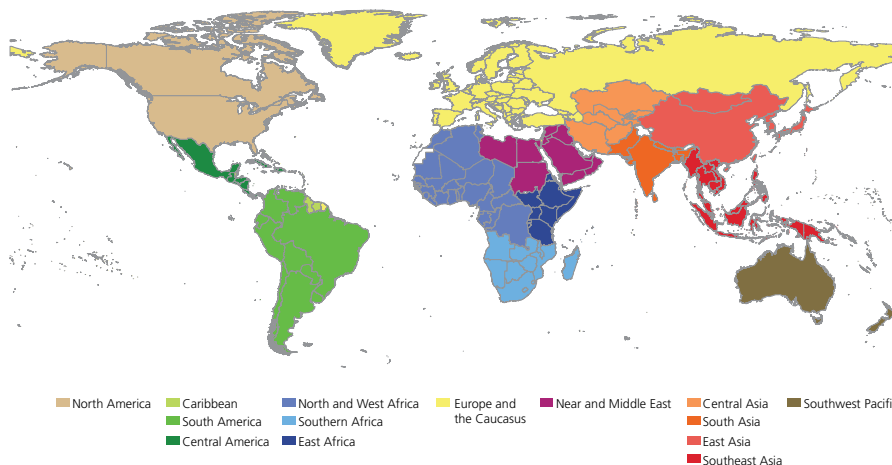
<sup>22</sup> <http://fao.org/dad-is>

<sup>23</sup> <http://faolex.fao.org/>

<sup>24</sup> <http://faostat.fao.org/>

FIGURE 1

**Assignment of countries to regions and subregions in this report**



FAO/INFOODS Food Composition Database for Biodiversity (BioFoodComp)<sup>25</sup> and the UN Comtrade Database.<sup>26</sup> The analysis of DAD-IS data for Part 1 Section B of the report (Status and trends of AnGR) was carried out in July 2014.

**Regional classification of countries**

The assignment of countries to regions and subregions for the purposes of the second SoW-AnGR follows the assignment used in the first SoW-AnGR (see Figure 1). This assignment was based on a number of considerations, including production environments, cultural factors and the distribution of shared AnGR. Because of these various considerations, the regional groupings do not correspond exactly to the standard FAO regions used in FAO statistics and for FAO election purposes (although for most countries the assignment does not differ from the standard classification).

Seven regions are distinguished, three of which are further subdivided into subregions:

- Africa (East Africa, North and West Africa, Southern Africa);
- Asia (Central Asia, East Asia, Southeast Asia, South Asia);
- Europe and the Caucasus;
- Latin America and the Caribbean (Caribbean, Central America, South America);
- the Near and Middle East;
- North America; and
- the Southwest Pacific.

<sup>25</sup> <http://www.fao.org/infoods/infoods/tables-and-databases/faoinfoods-databases/en/>

<sup>26</sup> <http://comtrade.un.org>



# Summary

## About this report

*The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture* provides a comprehensive assessment of the state of livestock biodiversity and its management. It sets out the latest available information on the origin and history of animal genetic resources (AnGR), trends in the status of AnGR, the uses, roles and values of AnGR, the adaptive characteristics of AnGR and threats to AnGR diversity. It presents an overview of livestock-sector trends and their effects on AnGR and their management. It describes the state of capacity to manage AnGR and the state of the art in methods and strategies for their management. It reviews progress made in the implementation of the Global Plan of Action for Animal Genetic Resources, adopted in 2007 as the first internationally agreed framework for the management of livestock biodiversity. It ends with an assessment of gaps and needs in AnGR management.

The report draws on information provided in 129 country reports, 15 reports from international organizations, 4 reports from regional focal points and networks for AnGR management and inputs from 150 authors and reviewers. It is intended to serve as an update of the first report on *The State of the World's Animal Genetic Resources for Food and Agriculture*, published in 2007, and focuses particularly on developments since the first report was prepared.

## Key findings

### ***Livestock diversity facilitates the adaptation of production systems to future challenges and is a source of resilience in the face of greater climatic variability***

Livestock production systems face many challenges. The precise demands that will be placed on the livestock of the future are difficult to predict. However, coping with climate change, new disease challenges, restrictions on the availability of natural resources and changing market demands will require a diverse range of AnGR. Adaptedness to harsh conditions and resilience in the face of extreme climatic events and other shocks are likely to be important. Potential synergies in efforts to promote sustainable AnGR management, improve livelihoods and achieve environmental objectives need to be exploited. Appropriate management strategies require better knowledge of the roles, uses and values of AnGR, particularly in the livelihoods of poor people, and better knowledge of the effects of livestock on ecosystem functions.

### ***The roles and values of animal genetic resources remain diverse, particularly in the livelihoods of poor people***

While livestock's roles in the provision of some products and services are gradually being replaced as alternative sources become more widely available, the use of livestock remains very diverse. There is a need to understand these diverse roles and how they are changing. This will help ensure that AnGR are well matched to the needs of livestock keepers and society. It will also help identify potential threats to AnGR diversity arising because particular breeds are no longer valued for their former functions and may therefore face an increased risk of extinction. Livestock's roles in the provision of ecosystem services related to the regulation of ecological functions, landscape management and the provision of wildlife habitats remain under-researched and undervalued. Interest in the connection between genetic diversity and the nutritional contents of animal-source foods for human consumption is increasing, but this field has not yet received much research attention.

***The adaptations of specific species and breeds to specific environmental challenges need to be better understood***

The adaptive characteristics of individual breeds (e.g. ability to cope well with extremes of temperature, restricted water supply, poor-quality feed, rough terrain, high elevations and other challenging aspects of the production environment) have generally not been studied in great depth. Some progress has been made over recent years in terms of expanding our understanding of the genetics of disease resistance and tolerance, including the relative susceptibilities of specific breeds to specific diseases. However, many reported instances of resistance or tolerance remain anecdotal (i.e. have not been evaluated in scientific studies). Lack of information remains the major constraint to the integration of genetic approaches into disease-control strategies.

***The world's livestock diversity remains at risk***

The proportion of livestock breeds classified as being at risk of extinction increased from 15 percent to 17 percent between 2005 and 2014. A further 58 percent of breeds are classified as being of unknown risk status because no recent population data (from the last ten years) have been reported to FAO. The number of breeds at risk is therefore likely to be underestimated. Monitoring of population trends is a prerequisite for prompt and effective action to protect breeds from extinction. Erosion of within-breed diversity can be a problem even in breeds whose total population size remains very large.

***The assessment of threats to animal genetic resources needs to be improved***

Action to prevent the loss of livestock diversity will be more effective if the factors that drive genetic erosion and extinction risk are well understood. While there is considerable agreement among stakeholders regarding the range of factors that can be considered potential threats to AnGR diversity, the magnitude of these threats and the ways in which they combine to affect particular breeds in particular circumstances are often unclear. Information provided in the country reports suggests that indiscriminate cross-breeding, economic drivers and changing market demands, weaknesses in AnGR management programmes, policies and institutions, degradation of natural resources (or problems with access to such resources), climate change and disease epidemics are major threats.

***Institutional frameworks for the management of AnGR need to be strengthened***

While progress has been made in terms of improving the basic prerequisites for effective AnGR management at national level (adequate physical infrastructure, effective mechanisms for stakeholder participation, high-quality education and research programmes, good knowledge and awareness of AnGR-related issues, and appropriate legal and policy frameworks and capacity to implement them) many weaknesses remain, particularly in developing countries. While a number of examples of international cooperation in research and other aspects of AnGR management are described in the country reports, international collaboration remains a relatively underdeveloped element of the implementation of the Global Plan of Action.

***Establishing and sustaining effective livestock breeding programmes remains challenging in many countries, particularly in the low-input production systems of the developing world***

Implementing a livestock breeding programme is a challenging task that involves a number of different elements. Over recent years, a number of countries have made progress in terms of putting some of these elements in place (e.g. the establishment of animal identification and registration schemes). However, the country reports indicate that, in developing regions

in particular, these elements do not always form part of coherent genetic improvement programmes for the breeds concerned. Even where programmes exist, they are often of a rudimentary nature and operate on a limited scale. A lack of adequate organizational structures for the involvement of livestock keepers and breeders in the planning and implementation of breeding schemes often inhibits the establishment of more effective programmes.

***Conservation programmes for animal genetic resources have become more widespread, but their coverage remains patchy***

Most countries that participated in the reporting process indicate that they now have at least some AnGR conservation activities in place. *In vitro* gene banks have been established by 64 countries and a further 41 countries are planning to do so. Many of these gene banks are in the early stages of development and the collections often have many gaps in their coverage of relevant breeds and populations. The coverage of *in situ* conservation activities (actions that support the maintenance of livestock populations in their usual production environments) is also incomplete. However, a diverse range of different activities are reported. For example, countries increasingly report the development of niche markets for speciality products as a means of increasing the profitability of potentially threatened breeds.

***Emerging technologies are creating new opportunities and challenges in animal genetic resources management***

Substantial advances have been made in genomic technologies over recent years. These technologies have improved understanding of the genetic basis of heritable traits and have increased the efficacy of some breeding programmes. However, in global terms, the impact of these technologies has been largely limited to certain international transboundary breeds kept in high-input systems. Although various circumstances influence the applicability of these tools, a primary facilitating factor is the availability of phenotypic and pedigree data. Increasing the collection of these data is of critical importance, not only for the effective use of genomics, but for any type of genetic improvement or conservation programme.

***The impact of many livestock sector trends on animal genetic resources and their management is increasing***

The major changes that have affected the global livestock sector over recent decades – including the rapid expansion of large-scale high-input production systems in parts of the developing world, growing pressures on natural resources, the partial replacement of some of livestock's roles as alternative sources of provision become available, and changes in the livelihood and lifestyle opportunities available to rural people – have had a substantial impact on AnGR and their management. Countries generally report that they expect such effects to be even greater in the coming years than they have been in the recent past. Growth in demand for animal-source food continues to create major challenges for the sustainable use of AnGR. South Asia and Africa are projected to become the main centres of growth in meat and milk consumption. These are very resource-constrained regions that are home to many small-scale livestock keepers and pastoralists and to a diverse range of AnGR. Other drivers of change predicted to have a major effect on AnGR management in the coming years include climate change, technological developments and policy factors. Keeping track of trends of this kind and identifying their potential effects on demand for particular species and breeds and on capacity to maintain a diverse portfolio of livestock diversity is an important part of planning the long-term sustainable management of AnGR, both at national level and globally.



***Livestock diversity and the sustainable management of animal genetic resources are acquiring a greater foothold on policy agendas***

Despite the limited amount of time available for reporting, 129 countries submitted country reports for use in the preparation of this report. As of May 2015, 177 countries had nominated National Coordinators for the Management of AnGR and 112 report that they have prepared, are in the process of preparing or are planning to prepare national strategies and action plans for AnGR. Many countries report that they have developed legal instruments or policies targeting improvements to the management of AnGR. At international level, the importance of genetic resources for food and agriculture, including AnGR, has been highlighted in several major initiatives and agreements (e.g. the Convention on Biological Diversity's Strategic Plan for Biodiversity 2011–2020 and Aichi Targets, and the draft post-2015 development goals).

**What needs to be done?**

Strategic priorities for action in the management of AnGR are set out in the Global Plan of Action for Animal Genetic Resources. The analysis presented in this report suggests that these strategic priorities remain relevant.

Efforts still need to be made to strengthen the main elements of sustainable AnGR management. Priorities include:

- improving knowledge of the characteristics of different types of AnGR, the production systems in which they are kept and the trends affecting these production systems;
- developing stronger institutional frameworks for AnGR management, including mechanisms that allow for better communications among stakeholders and facilitate the participation of livestock keepers in the planning and implementation of AnGR-related policies and programmes;
- improving awareness, education, training and research in all areas of AnGR management, including in the emerging fields of access and benefit sharing, ecosystem services and climate change adaptation and mitigation;
- strengthening breeding strategies and programmes so as to enable full advantage to be taken of available genetic diversity and ensure that AnGR are well matched to their production environments and to societal needs; and
- expanding and diversifying conservation programmes, where possible combining approaches that provide for ongoing use of livestock breeds in their usual production environments with those that provide for backup storage of genetic material.

National strategies and action plans for AnGR provide a means of translating the provisions of the Global Plan of Action into well-targeted activities that meet specific needs at country level. Countries that have not yet developed a national strategy and action plan should consider doing so. Countries that have already developed such instruments should ensure that they are implemented. In many cases, improving AnGR management at national level will also require strengthening National Focal Points for the Management of Animal Genetic Resources.

In addition to individual strategic priorities, the Global Plan of Action also addresses the question of implementation and funding, emphasizing the need for long-term commitment and the need to devote substantial and additional financial resources to improving the sustainable management of AnGR. Many country reports stress that lack of funding is a major constraint to the improvement of many aspects of AnGR management. These funding gaps need to be addressed.

The Global Plan of Action also emphasizes the importance of international cooperation in AnGR management. There is a need to strengthen global- and regional-level activities related both to the management of shared resources (transboundary breeds) and to the transfer of technologies and knowledge that facilitate the sustainable use, development and conservation of AnGR.