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منظمة الأغذية والزراعة للأمم المتحدة

COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE

Item 2 of the Provisional Agenda

Eighteenth Regular Session

27 September – 1 October 2021

BIODIVERSITY FOR FOOD AND AGRICULTURE FOR FOOD SECURITY, NUTRITION AND HUMAN HEALTH

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I. INTRODUCTION

1. In its review of the Multi-Year Programme of Work (MYPOW), the Commission on Genetic Resources for Food and Agriculture (Commission), at its Sixteenth Regular Session in 2017, took note of the many interactions between agricultural production, biodiversity for food and agriculture (BFA) and human health besides the direct effects on nutrition[1] and added to the MYPOW the development of a concept note on BFA and human health for consideration at its Eighteenth Regular Session. It also added the element of health to its workstream on nutrition.[2]

2. At its Seventeenth Regular Session, the Commission, in considering Background Study Paper No. 69 *Biodiversity for food and agriculture and food security – An exploration of interrelationships*,[3] requested the Secretariat to prepare a brochure on the contribution of GRFA to food security and to the achievement of relevant Sustainable Development Goals (SDGs).

3. This document reports on progress in the Commission's work on food security, nutrition and health since the Commission's last Session and presents a concept note on BFA and human health for consideration by the Commission. The document *FAO Activities on biodiversity for food and agriculture for food security, nutrition and human health*[4] reports on FAO activities on BFA and GRFA, food security and nutrition; it also reports on FAO activities on BFA and human health within a rapidly changing global policy landscape. Upon review by the Commission's Bureau, the brochure *How the world's food security depends on biodiversity* was made available in all UN languages in 2020.[5]

II. ACTIVITIES ON BIODIVERSITY FOR FOOD AND AGRICULTURE AND FOOD SECURITY AND NUTRITION

4. The role of genetic resources for food security and nutrition is an item the Commission keeps under permanent review.

5. Following the request by the Commission at its last Session,[6] the Secretariat invited, through Circular State Letter C/CBD-10, Members and observers to report on: experiences in the development and implementation of policies related to biodiversity and nutrition; and best practices and lessons learned in mainstreaming biodiversity into nutrition policies and programmes, and traditional food knowledge. The Secretariat received no submissions.

6. Following the Commission's request,[7] outcomes of the last Session were shared with the Secretariat of the CFS. The *Voluntary Guidelines on Food Systems and Nutrition,*[8] endorsed by the CFS at its 47th Session in February 2021, recognize that BFA enhances the sustainability of food systems and their resilience and contributes to safeguarding healthy diets for current and future generations. This is captured under a guiding principle on "Healthy and prosperous people, healthy planet". The guidelines call for interventions within and across food systems, and their constituent elements – food supply chains, food environments and consumer behaviour – to enhance the livelihoods, health and well-being of populations; encourage sustainable food production and responsible consumption of safe, diverse and nutritious foods; protect and promote sustainable use of natural resources, biodiversity and ecosystems; and support mitigation and adaptation to climate

[1] CGRFA-16/17/22, paragraph 26.
[2] CGRFA-16/17/Report Rev.1, *Appendix C*; CGRFA-17/19/Report, *Appendix F*, Annex 1
[3] Rawal, V., Bansal V. & Thokchom, D. 2019. *Biodiversity for food and agriculture and food security: an exploration of interrelationships*. Background Study Paper No.69. FAO Commission on Genetic Resources for Food and Agriculture. Rome. (also available at http://www.fao.org/3/CA3218EN/ca3218en.pdf).
[4] CGRFA-18/21/2/Inf.1.
[5] FAO. 2020. *How the world's food security depends on biodiversity*. Rome. (also available at http://www.fao.org/documents/card/en/c/cb0416en).
[6] CGRFA-17/19/Report, paragraph 36.
[7] CGRFA-17/19/Report, paragraph 38.
[8] CFS. 2021. Voluntary Guidelines on Food Systems and Nutrition. Rome. (also available at http://www.fao.org/fileadmin/templates/cfs/Docs2021/Documents/CFS_VGs_Food_Systems_and_Nutrition_Strategy_EN.pdf).

change, as appropriate. They also present agreed text on key concepts such as healthy and unhealthy diets, nutritious foods, and sustainable food systems.

7. The information document *FAO Activities on biodiversity for food and agriculture for food security, nutrition and human health*[9] demonstrates the breadth and depth of FAO's work in nutrition, with an increasing focus on healthy diets.[10] FAO's work on nutrition is developed and implemented in partnership with other organizations. Nutrition has been mainstreamed as a cross-cutting theme in the FAO Programme of Work and Budget since 2016.[11] The information document shows that FAO's activities on biodiversity and nutrition linkages have increased over the past years and so has their visibility. Biodiversity is increasingly addressed across FAO's activities on nutrition; healthy diets need to be balanced and diverse. There is, however, little recognition that diversity at genetic level, e.g. different varieties of the same crop, have different dietary effects, including on human health.

III. CONCEPT NOTE ON BIODIVERSITY FOR FOOD AND AGRICULTURE AND HUMAN HEALTH

8. Contrary to the work on GRFA and food security and nutrition, the linkages between BFA and human health are a new theme that the Commission decided to consider at its Sixteenth Regular Session in 2017.

9. Since 2017, global developments, specifically the Covid-19 pandemic, and developments within FAO have placed strong emphasis on One Health. One Health is an integrated approach that recognizes that the health of animals, people, plants and the environment are interconnected and ensures that specialists from multiple sectors communicate, design and implement programmes, policies, legislation and research, and work together to achieve better health outcomes for animals, people, plants and the environment.[12] It is a holistic cross-sectoral and interdisciplinary approach that seeks to examine interconnections among human and ecosystem health. The One Health approach has been increasingly applied in food safety, the control of zoonoses and the wildlife–livestock–human interface, fisheries health, and in combatting antimicrobial resistance (AMR). One Health offers opportunities to mainstream biodiversity in the human, animal and plant health communities, paying greater attention to preventive measures based on strengthening the resilience of socio-ecological systems, and greater consideration of a broader concept of health beyond the absence of diseases.[13] In FAO, it has been especially applied in animal health since the Avian influenza epidemics in the early 2000s and, as mentioned above, in sustainable wildlife management.

10. Biodiversity supports human health in many ways, including through the delivery of basic goods and services, sustained by well-functioning ecosystems. The information document[14] also shows the extent of FAO's work in One Health. It indicates that FAO's visibility and mandate on biodiversity and One Health linkages have increased over the past years. FAO's work on One Health is developed and implemented with strong partner organizations, such as the World Health Organization (WHO) and the World Organisation for Animal Health (OIE) and the Convention on Biological Diversity (CBD).

11. BFA and human health interactions occur at various levels, from production to consumption of food, from the ecosystem with complex host-(vector)-pathogen relationships to individual levels of disease resistance, and down to the microbiome. Looking at the different levels of BFA, the following sections describe some selected aspects of the interlinkages between BFA and human health, starting with the important contributions to food security and nutrition, followed by infectious and parasitic diseases.

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[9] CGRFA-18/21/2/Inf.1.
[10] https://www.who.int/news-room/fact-sheets/detail/healthy-diet
[11] C 2015/3.
[12] https://www.who.int/news-room/q-a-detail/one-health , http://www.fao.org/one-health/en/
[13] CBD/SBSTTA/21/9.
[14] CGRFA-18/21/2/Inf.1.

Food security and nutrition aspects of human health

12. As previously demonstrated, GRFA contribute to all four pillars of food security: availability, access, utilization and stability. At **production** level, GRFA between and within species differ with regard to their average yields and their susceptibility to diseases. Production diseases (diseases induced by management practices, e.g. metabolic diseases, mastitis) and infectious and parasitic diseases are all affecting pre-harvest losses. Regarding BFA, invasive alien species and emerging infectious diseases, including those propelled by climate change, may also affect food availability and quality through crop yield losses and reductions in livestock production (e.g stem borers, leaf miners, bluetongue disease, African Swine Fever, a range of bee diseases (e.g. *Varroa spp*), a range of fish diseases). Crop and livestock pests, diseases and infestations are estimated by the FAO to have caused 9 percent of all production losses from 2008 to 2018.[15]

13. Pathogens from food production and processing also affect **food safety**. The WHO estimates that unsafe food containing harmful bacteria, viruses, parasites or chemical substances causes more than 200 diseases – ranging from diarrhoea to cancers, with diarrhoeal diseases causing illness of 550 million people and 230 000 deaths every year.[16] Another example are aflatoxins that can contaminate food crops both before and after harvest. They not only cause an estimated 25 percent of the world's food crops to be destroyed annually, but long-term or chronic exposure to aflatoxins can have serious health consequences. Biological control using non-toxigenic *Aspergillus flavus* isolates is a strategy that has received significant attention for reduction of aflatoxins prior to harvest.[17]

14. **Healthy diets** are important for a healthy life; they can be achieved by a diversity of different food items, at species and subspecies levels. Although there are differences between the nutrient content of different varieties and breeds i.e. diversity at the GRFA level, and animal pollination leads to more nutrient-rich foods, nutrition recommendations rarely go beyond the level of species diversity: they would usually stress the importance of consuming different types of vegetables; only rarely would they recommend to eat apples of different varieties or meat products from different breeds of chicken. There is, however, evidence that nutrient levels may vary considerably across different varieties/breeds of one and the same species,[18] and that they can be enhanced through breeding, incl. "biofortification" (e.g. β-carotene-rich orange sweet potato). Nutritional deficiencies accounted for 0.5 percent of all human deaths in 2019.[19]

15. Within the body, the human (and livestock) **gut microbiome** has been attracting increasing attention. The Human Microbiome Project,[20] started in 2007, links interactions between humans and their microbiomes to health-related outcomes. Modern biotechnologies and bioinformatics have allowed for improved understanding of the microbiome, metabolic functions, immunology and epidemiology. Human microbiomes seem to be largely individual, differ between environments and populations, and influence a range of health conditions, as well as immunological mechanisms and the efficacy of drugs.[21] However, many knowledge gaps in microbiome-linked health states remain, and subsequently, gaps for the application of personalized diets.

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[15] After storms (18 percent) , floods (19 percent) and droughts (34 percent), see http://www.fao.org/home/digital-reports/disasters-in-agriculture/en/

[16] https://www.who.int/news-room/fact-sheets/detail/food-safety

[17] https://www.who.int/foodsafety/FSDigest_Aflatoxins_EN.pdf

[18] INFOODS food composition database, http://www.fao.org/infoods/infoods/tables-and-databases/faoinfoods-databases/it/ ; Barnes K., T. Collins, S. Dion, H. Reynolds, S. Riess, A. Stanzyk, A. Wolfe, S. Lonergan, P. Boettcher, U.R. Charrondiere, B. Stadlmayr, Importance of cattle biodiversity and its influence on the nutrient composition of beef, *Animal Frontiers*, Volume 2, Issue 4, October 2012, Pages 54–60, https://doi.org/10.2527/af.2012-0062

[19] WHO. 2020. *Global Health Estimates 2020: Deaths by Cause, Age, Sex, by Country and by Region, 2000-2019*. Geneva. https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/ghe-leading-causes-of-death)

[20] https://www.hmpdacc.org/

[21] The Integrative HMP (iHMP) Research Network Consortium. 2019. The Integrative Human Microbiome Project. *Nature*, 569: 641–648. https://doi.org/10.1038/s41586-019-1238-8

16. Between 2000 and 2019, the share of non-communicable diseases in total human deaths has increased from 61 to 74 percent. Nutrition- and lifestyle-related non-communicable diseases increased most, with 32 percent of deaths arising from cardiovascular and 2.7 percent from diabetes mellitus in 2019.[22] Disability-adjusted life years (DALYs) from diabetes increased by more than 80 percent between 2000 and 2019. This means that the impacts of rather unspectacular daily consumption decisions have the biggest, and increasing, human health impact globally.

Infectious and parasitic disease aspects of human health

17. Most infections are caused by bacteria, viruses, protozoa, helminths, rickettsia and fungi, organisms that could be considered the undesired part of BFA. However, knowledge and characterization of these organisms is essential for the development of any strategy to address their effects on human health. Infectious disease symptoms may also be less dramatic when the immune system of the host is healthy and fully functional – an aspect that relates to the nutrition part above.

18. In 2019, infectious and parasitic diseases caused about 14 percent of all human deaths (of which 4.7 percent respiratory infections, 2.7 percent diarrhoeal diseases; 2.2 percent tuberculosis, 1 percent parasitic and vector diseases, and others).[23] Despite their lower share of total deaths and DALYs, infectious diseases, especially emerging infectious diseases (EID) (e.g. SARS, Ebola, MERS, Nipah, COVID-19), attract far more public attention than non-communicable, nutrition-related diseases. One reason is that about 60 percent of all EID are zoonotic – they are caused by pathogens shared between humans and other vertebrates. Most pathogens that spill over to humans have multiple non-human hosts, and certain taxa (e.g. rodents, bats, primates and carnivores) appear to be most responsible for zoonotic pathogens, either as the original source of a pathogen or as a secondary host with elevated contact with humans.[24]

19. Also, the number of EID has risen significantly during the last decades and is expected to increase further, driven by correlated socio-economic, environmental and ecological factors, including climate change and globalization. Between 1940 and 2004, over 300 emerging disease events were identified in humans and, globally, almost half of these diseases resulted from changes in land use, intensification of agricultural practices and changes in food production practices, or from wildlife hunting. Also, about half of the EID events were caused by bacteria or rickettsia, reflecting a large number of drug-resistant microbes.[25]

20. Disease regulation is an important **ecosystem** service provided by biodiversity, and the ecology of infectious disease is increasingly being studied.[26] Many pathogens are "generalists" with a wide host range. These host species differ in their susceptibility to infection, but also in their potential to transmit infection to other hosts and to remain reservoir hosts. The dynamics of such multi-host diseases can change dramatically with a change in host species richness or abundance, either reducing or increasing the risk of disease transmission to different host species.

21. On one hand, areas of naturally high biodiversity may serve as a source pool for new pathogens. There is evidence for the "amplification effect" that increasing biodiversity increases disease risk.[27]

22. On the other hand, the so-called "dilution effect" refers to the disease-buffering role of high host diversity; it has been studied in plant and wildlife diseases but is also known to be prevalent in human pathogens. The dilution effect is assumed to have a stronger impact with vector-borne

[22] WHO. 2020. ibid
[23] WHO. 2020. ibid
[24] Keesing, F. & Ostfeld, S. 2021. Impacts of biodiversity and biodiversity loss on zoonotic diseases. *PNAS* 118, No. 17, https://doi.org/10.1073/pnas.2023540118
[25] Jones, K.E., Patel, N.G., Levy, M.A., Storeygard, A., Balk, D., Gittleman J.L. & Daszak, P. 2008. Global trends in emerging infectious diseases. *Nature,* 451: 990–993. https://doi.org/10.1038/nature06536
[26] IPBES. 2020. *Workshop Report on Biodiversity and Pandemics of the Intergovernmental Platform on Biodiversity and Ecosystem Services.* P. Daszak, C. das Neves, J. Amuasi, D. Hayman, T. Kuiken, B. Roche, C. Zambrana-Torrelio *et al.* IPBES secretariat, Bonn, Germany, DOI:10.5281/zenodo.4147317.
[27] Johnson, P.T.J, Ostfeld, R.S. & Keesing, F. 2015. Frontiers in research on biodiversity and disease, *Ecol Lett.* 18(10): 1119–1133. doi:10.1111/ele.12479.

pathogens; when species-rich communities are not associated with increased host density; and when the host species tends to remain in case overall species diversity declines.

23. The many advantages for maintaining or even increasing biodiversity might outweigh the risks posed by the amplification effect. There is evidence that biodiversity loss often increases disease transmission. Thus, the dilution effect has attracted attention in the context of global biodiversity decline and increasing emergence of infectious diseases, especially zoonotic diseases. The complex role of land-use changes, including forest conversion and habitat fragmentation is important in the biodiversity–disease nexus from an epidemiological, evolutionary and from an ecological perspective. A recent study associated increases in outbreaks of zoonotic and vector-borne diseases from 1990 to 2016 with deforestation (mostly in tropical countries) and with reforestation (mostly in temperate countries), and outbreaks of vector-borne diseases with an increase in palm oil plantation areas.[28] However, forest-derived infections are relatively unexplored, and both taxonomically and geographically biased. The role of biodiversity for infectious and parasitic diseases raises key questions:

- What are the effects of natural levels of biodiversity and the effects of changes to pathogen diversity, for example, through human impacts?
- To what extent does a reduction of the genetic diversity of the host impact the ability of the host population to response to infectious diseases?
- What are the biodiversity–disease relationships across different scales and within the multiple effects of land-use change and habitat fragmentation?
- How do different anthropogenic impacts (e.g. habitat conversion, climate change, overharvesting) affect hosts and disease ecology?
- Is there a role of the dilution effect in the emergence of antimicrobial resistance (AMR), and could this be effect brought to bear on production practices?
- Will policies that prevent the loss of biodiversity simultaneously promote health protection?

24. Moving from the ecosystem level to the **host species and genetic level**, there are different levels of genetic resistance of the host to diseases due to their co-evolutionary history. Resistance is the ability of the host to exert some degree of control over different steps of the pathogen life cycle, and improved resistance impacts on the individual and on its entire population (e.g. via reduced disease transmission).

25. The heritability of resistance traits varies among host species/varieties/breeds and types of pathogens but is usually low, and incomplete exposure to infection means that some individuals do not have the opportunity to express their resistance genotype. Therefore, the provision of adequate phenotypic data and their interpretation are often limitations in disease genetic studies.

26. However, modern biotechnologies and bioinformatics allow for the improved understanding of molecular and resistance mechanisms. In crops, breeding for disease resistance is an important strategy for the reduction of yield losses, in which usually multiple and diverse resistance genes combined are targeted for long-lasting resistance.[29] While evolutionary potential of tree species exists to respond to new emerging diseases, and conventional breeding has obtained resistant genotypes in forestry, genetic engineering has become a viable approach to develop resistance against pests and pathogens in forest trees. The risk of increased levels of inbreeding and loss of genetic diversity caused by low population sizes are major concerns.

27. In livestock breeding, it is difficult and costly to measure host resistance, as disease resistance generally cannot be directly measured on breeding candidates (animals must be exposed to the

[28] Morand, S. & Lajaunie, C. 2021. Outbreaks of vector-borne and zoonotic diseases are associated with changes in forest cover and oil palm expansion at global scale. *Front. Vet. Sci.* 8:661063. doi: 10.3389/fvets.2021.661063
[29] Nelson, R., Wiesner-Hanks, T., Wisser, R. & Balint-Kurti, P. 2018. Navigating complexity to breed disease-resistant crops. *Nat. Rev. Genet.,* 19: 21–33. https://doi.org/10.1038/nrg.2017.82

pathogen and develop disease symptoms to accurately measure the resistance phenotype). However, for some diseases, it may be possible to measure resistance traits on sufficient numbers of animals and economically worthwhile to incorporate these traits into breeding strategies.[30] This is different in aquaculture, where the highly fecundity of most species and the typically low economic value of juveniles allow for mass- or family selection.[31] In both livestock and aquaculture, genomic selection is today the state-of the art in disease resistance breeding.

28. As with the human microbiome, the **microbiomes** of plants and animals influence host health. In plants, root-invading beneficial microbes, including rhizobia and arbuscular mycorrhiza, can establish a mutualistic relationship with their host.[32] Endophytic bacteria can indirectly improve plant health by priming plant defences and by targeting pests and pathogens with antibiotics, hydrolytic enzymes and nutrient limitation.[33] Associations of trees with endophytic and subterranean microbes play a critical role in tree health. Future research on the role of endophytic communities will provide insight into how to manage and maintain forests with high resilience and may in the future be engineered in forest trees to improve resistance.

29. **Pest and pathogen intraspecific diversity** is a crucial factor in disease emergence and allows pathogens to genetically adapt to the selective pressures they face. This is a particular problem for endemic infectious diseases that have been under selection pressure from traditional disease control strategies for the last decades. These control strategies are failing, as evidenced by worldwide infestations with widespread acaricide, anthelmintic, herbicide and insecticide resistance, and the same can be said about AMR.

30. Anthelmintic resistance in gastrointestinal nematodes has been reported worldwide in multiple nematode species, against most anthelmintic classes and sometimes simultaneously multiple different classes.[34] The International Herbicide-Resistant Weed Database[35] lists 502 unique cases of herbicide-resistant weeds globally, with 263 species. Herbicide-resistant weeds have evolved resistance to 164 different herbicides and have been reported in 95 crops in 71 countries. The Insecticide Resistance Action Committee,[36] a technical group of the industry association CropLife that provides a coordinated response to prevent or delay the development of resistance in insect pests, noted that, since the 1940s, the number of insect species with reported insecticide resistance has been rapidly increasing and recently passed 580 species.[37] For example, the pollen beetle (*Meligethes aenes*), a key pest of oilseed rape in Europe, shows more than 515 individual cases of resistance across 27 different insecticides, and populations of diamondback moth (*Plutella xylostella)* have developed resistance to nearly all insecticides used against them. The emergence of multi-drug-resistant strains of ectoparasitic sea lice is not only a threat to aquaculture, but also affects wild fish (e.g. salmon).

31. WHO declared AMR as “one of the top ten global public health threats facing humanity”, with significant economic costs. In 2019, a new AMR indicator was included in the SDG monitoring framework.[38] Antimicrobial resistant organisms are ubiquitously found in people, animals, food, plants and the environment (in water, soil and air).

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[30] Bishop, S.C. & Woolliams, J.A. 2014. Genomics and disease resistance studies in livestock. *Livestock Science,* 166: 190–198. doi: 10.1016/j.livsci.2014.04.034

[31] Houston, R. 2017. Future directions in breeding for disease resistance in aquaculture species. *R. Bras. Zootec.* 46 (6) https://doi.org/10.1590/S1806-92902017000600010

[32] See CGRFA-18/21/11.2/Inf.1.

[33] Afzal, I., Shinwari, Z.K., Sikandar, S. & Shahzad, S. 2019. Plant beneficial endophytic bacteria: Mechanisms, diversity, host range and genetic determinants, *Microbiological Research*, 221: 36–49, https://doi.org/10.1016/j.micres.2019.02.001.

[34] Vineer, R.H., Morgan, E.R., Hertzberg, H., Bartley, D.J., Bosco, A., Charlier, J., Chartier, C. *et al*. 2020. Increasing importance of anthelmintic resistance in European livestock: creation and meta-analysis of an open database. *Parasite (Paris, France)*, *27*, 69. https://doi.org/10.1051/parasite/2020062

[35] http://www.weedscience.org/Home.aspx

[36] https://irac-online.org

[37] Sparks, T.C. & Nauen, R. 2015. IRAC: Mode of action classification and insecticide resistance management. *Pestic. Biochem. Physiol*., 121: 122–128.

[38] https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance

32. At all levels of biodiversity, “omics” and metagenomic investigations are encouraging for the description of pathogens, their communities and their interactions with hosts.

Options for the Commission to consider biodiversity for food and agriculture and human health

33. FAO’s work on One Health (as on nutrition) is targeting the broader biodiversity rather than the BFA or GRFA level; the latter are often mentioned in general statements that point to exploitation of genetic diversity as an adaptation option (e.g. resistance breeding). The prevailing lack of references to and evidence of information below production system/species levels impedes specific analyses of or action on the contribution of BFA and GRFA to nutrition and health outcomes.

34. Within the crowded policy and implementation landscape on One Health, and considering the lack of information at the genetic level, the Commission may wish to be kept informed about developments and request FAO to strengthen the GRFA aspects in ongoing work on One Health.

35. The Commission may further consider the nutrition or the infectious diseases part or both in its future work. It may further wish to consider the level of BFA to be addressed in its future work on health (i.e. the ecosystem/production system, species or genetic level).

36. In view of the important role of the microbiome, the Commission may wish to add this topic to its Work Plan for the sustainable use and conservation of micro-organism and invertebrate genetic resources for food and agriculture. It may also wish to consider the management of pests and pathogens, the “undesired” BFA diversity, in this Work Programme.

IV. GUIDANCE SOUGHT

37. The Commission may wish to:

i. request FAO to monitor developments related to the different levels of human health, biodiversity and nutrition and report back to the Commission as appropriate;

ii. request FAO to continue collaboration with its partners on healthy diets and nutrition, and plant, animal and human health, and to raise awareness of the importance of genetic diversity for food and agriculture in these fora and for emerging policies and action plans;

iii. request FAO to strengthen its support to Members in their strive for food security, nutrition and One Health with improved use of BFA and GRFA;

iv. consider adding pests and pathogens, and the human microbiome, to its Work Plan for the Sustainable Use and Conservation of Micro-organism and Invertebrate Genetic Resources for Food and Agriculture.