Food and Agriculture Organization of the United Nations

REPORT

WORKSHOP ON LOCUST DATA COLLECTION, ANALYSIS, FORECAST AND REPORTING IN CAUCASUS AND CENTRAL ASIA (CCA)

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Contents

Abbreviations and acronyms

ASDC	Automated System of Data Collection
CCA	Caucasus and Central Asia
CCALM	Caucasus and Central Asia Locust Management System
CIT	*Calliptamus italicus* (Linnaeus 1758), Italian Locust
DLIS	Desert Locust Information Service (FAO)
DMA	*Dociostaurus maroccanus* (Thunberg 1815), Moroccan Locust
ET	Economic Threshold
EVI	Enhanced Vegetation Index
IVI	Integral Vegetation Index
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographic Information System
GPS	Global Positioning System
ha	Hectare
HTC	Hydrothermal Coefficient
ISTT	Institute of Space Technique and Technologies (Almaty, Kazakhstan)
JICA	Japan International Cooperation Agency
LMI	*Locusta migratoria migratoria* Linnaeus 1758, Asian Migratory Locust
NSP	Plant Production and Protection Division (FAO)
NSPMD	”Locusts and Transboundary Plant Pests and Diseases” Team (FAO)
NDSI	Normalized Difference Snow Index
NDVI	Normalized Difference Vegetation Index
NDWI	Normalized Difference Water Index
RAMSES	Reconnaissance And Management System of the Environment of Schistocerca (Desert Locust national GIS)
TCP	Technical Cooperation Programme (FAO)
TCPf	Technical Cooperation Programme Facility (FAO)
ToT	Training-of-Trainers
SWAC	Commission for Controlling the Desert Locust in South West Asia (FAO)
SWARMS	Schistocerca WARning Management System (global Desert Locust GIS)
USSR	Union of Soviet Socialist Republics
USAID	United States Agency for International Development

OPENING

Introduction, round of presentation and adoption of the Agenda (Items 1 and 2)

1. The Workshop on locust data collection, analysis, forecast and reporting in Caucasus and Central Asia (CCA) took place online on 16-18 February 2022. It was organized by the Food and Agriculture Organization of the United Nations (FAO) in the framework of the interregional and multi-funded "Programme to improve national and regional locust management in Caucasus and Central Asia (CCA)".

2. The following ten countries participated in this Geographical Information System (GIS) Workshop: Afghanistan, Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Russian Federation, Tajikistan, Turkmenistan and Uzbekistan. Participants also included Representatives from FAO headquarters and decentralized offices as well as an observer of Chinese Academy of Science and the Software developer from the Institute of Space Technique and Technologies (ISTT) Almaty, Kazakhstan. The list of participants is provided in Annex 1.

3. Mr Alexandre Latchininsky, Agricultural Officer/Locust Management, Locusts and Transboundary Plant Pests and Diseases Team (NSPMD), opened the Workshop and welcomed all participants. He said that this is third specialized GIS workshop organized; the first one had taken place in November 2019 in Uzbekistan thanks to the project funded by the United States Agency for International Development - USAID (GCP/GLO/963/USA) and the second one remotely in March 2021 thanks to project funded by the Japanese International Cooperation Agency - JICA (GCP/INT/384/JCA) and the FAO Regular Programme. He indicated that this third workshop is held thanks to support from JICA and the FAO Regular Programme. Its objectives are to discuss the practical use of the Automated System for Data Collection (ASDC) and the management of the "Caucasus and Central Asia Locust Management System" (CCALM), with a view to improve data collection, validation, analysis, forecast and reporting for early warning and timely locust control. Such Workshop also aims to improve the GIS in addition to promoting experience exchange, problem solving and network creation between designated Information Officers from CCA countries. The Workshop indeed targets specifically the staff responsible for the use and management of ASDC and CCALM at the national level, in the ten CCA countries covered by the FAO Programme.

4. A round of presentations allowed the Delegates from the ten participated countries to introduce themselves and afterwards the provisional agenda was presented and endorsed, as provided in Annex 2. The overview on the development, introduction and use of the locust GIS in CCA (2013-2021) was also briefly provided (given in Annex 3).

SESSION 1: LOCUST DATA COLLECTION

Use of the Automated System for Data Collection (ASDC) during the 2021 locust campaigns: challenges, solutions, etc. (Item 3)

5. Countries were invited to present ASDC use and related issues during the 2021 locust campaigns, including: availability of tablets/smartphones for ASDC use; training sessions and users; extent of use

(number of records and geographic coverage) during locust surveys and control operations; problems/difficulties met by staff; lessons learned and recommendations to improve ASDC functionalities.

6. The Delegate of Afghanistan informed that in 2021 about 270 persons were trained in nine southern provinces about Desert locust and the use of eLocust3m thanks to the financial support from FAO Commission for Controlling the Desert Locust in South West Asia (SWAC). Regarding ASDC data, which concern other locust pests in the north of the country, 234 records were uploaded during locust survey and 242 records during control operations in Baghlan, Balkh, Kunduz, Samangan and Takhar provinces in 2021. The Delegate informed that the difficulties met were connected with following: (1) lack of plant protection staff at district level; (2) weak Internet access and no electricity to charge tablet batteries in some areas; (3) some tablets were damaged in the field; (4) security problems and (5) although the authorities requested operators to use ASDC, the process is going slowly. The Delegate recommended to: cover Internet cost for six months for all tablets; organize national sessions once a year to facilitate coordination among operators and solve problems encountered during filling of survey and spray monitoring forms on ASDC; purchase an additional power bank per tablet; and repair the tablets which are not functioning properly.

7. The Delegate of Azerbaijan noted that four trainings on ASDC use were organized in 2021, by two Master-Trainers for a total of 69 specialists in Aghstafa and Saatli (14 June), in Samukh (24 June) and in Shaki (6 July) districts. ASDC was used during locust survey on 99 043 hectares - ha (64 percent of the entire surveyed area) and during control operations on 17 813 ha (60 percent). Thus 1302 Survey Forms and 298 Spray Monitoring Forms were sent to CCALM database. The records were made using 31 tablets. Among the difficulties, the available tablets for ASDC use at country level were insufficiently used. In addition, there have been changes in the management, which affected the quality of supervision of fieldwork. The intention is to improve the work in 2022 and increase the number of tablets used. Presently there are 61 tablets in Azerbaijan available for ASDC use, however, only a half of them is actually used.

8. The Delegate of Georgia underlined that in 2021, ASDC was used both, during locust survey and control operations. The Italian Locust (CIT) was widely distributed and the country faced a difficult situation. Locust experts made 488 records during locust survey and 1046 during treatments. The Delegate noted that thanks to ASDC and CCALM, it was easy to get information on locust survey, operatively react to complex situations and prepare the plan for control operations and control carrying out treatments. This helped to save time.

9. The Delegate of Kazakhstan informed that in 2021, a decline in the number of locusts was everywhere except for the Kostanay oblast. There is no ASDC data so far. It is planned to use the 20 tablets delivered by FAO in 2022 in the oblasts near the boundaries of neighboring countries. Presently Kazakhstan's own GIS system of plant pest and disease monitoring is under development. On 910 February 2022, a training of national GIS use was carried out by the developer, the Joint-Stock Company «National Company «Kazakhstan Gharysh Sapary».

10. The Delegate of Kyrgyzstan informed that the 20 tablets delivered by FAO in 2021 will be registered in CCALM and used during 2022 locust campaign. Presently the three Masters-Trainers who were

trained in 2017-2020 continue to work in plant protection service and follow-up on ASDC use. A total of 114 records were made during 2021, including 73 on tablets and 41 on paper forms. The latter ones will be inserted in CCALM database through WEB-interface. Most of ASDC data include locust survey information (59 forms). The Delegate underlined the necessity of annual national sessions before the locust campaign starts and of technical support of FAO to overcome problems.

11. The Delegate of the Russian Federation explained that Russian Agricultural Center (Rosselhozcenter) developed and uses its own digital phytosanitary monitoring system, which is connected with CCALM for the locust part. He indicated that in total, 764 ASDC records were made in 2021, mostly during survey operations, on 228 490 ha in Saratov, Orenburg and Volgograd oblasts and Stavropol territory, either on tablets or smartphones – more specifically: 288 ASDC records were made on 14 590 ha using 12 tablets in 12 districts of Saratov oblast; 62 records on 23 760 ha using three tablets in three districts of Stavropol Territory; 54 records on 2280 ha of three districts of Orenburg oblast; and 360 ASDC records on 187 860 ha using 30 smartphones in 25 districts of Volgograd oblast. The Delegate noted some difficulties in tablet use during field work, such as the bright sun making impossible to use the screen to enter information and the lack of mobile internet at some observation points.

12. The Delegate of Tajikistan remarked that five locust experts had been trained on locust management as well as ASDC and CCALM use in 2021. In Khatlon oblast, some difficulties were met in getting coordinates. Presently some new staff was recruited in this region who will be trained in ASDC use.

13. The Delegate of Turkmenistan remarked that the country just started ASDC learning and indicated that the 10 tablets delivered by FAO were locally distributed. During the last training, new and useful information was received. Many corrections and translations were executed for the ASDC and CCALM interfaces in Turkmen. In 2021, six test records were made during locust survey in Kopetdag.

14. The Delegate of Uzbekistan mentioned that 24 tablets and personal smartphones were used. He noted that an online training was delivered by FAO to specialists from 13 oblasts. In 2022, starting from 10 February, a total of 80 specialists were trained. Two specialists were selected as responsible persons for ASDC use in every oblast and two persons will also be appointed –by the Agency of Plant Protection and Quarantine, Uzbekistan.

15. Ms Nadiya Muratova, FAO International Consultant, GIS Expert, provided an overview of ASDC use in CCA during Programme Year 10 (1 October 2020 to 30 September 2021). She indicated that as of 30 September 2021, a total of more than 5000 reports had been made by 133 users from ten CCA countries (against a total of 4285 records from 100 users from eight countries in 2020). The GIS Expert also compared, for some countries, the area covered by ASDC against the total surveyed/treated areas, the situation being as followed: Afghanistan: 12,3 percent of surveyed areas and 9,6 percent of treated areas; Azerbaijan: 60,9 percent and 57,6 percent; Georgia: 33,7 percent and 60,5 percent; Kyrgyzstan: 52,1 percent and 17,1 percent; Tajikistan: 28,6 percent and 5 percent; and Uzbekistan: 7,3 percent and 9,8 percent (in 2021, Armenia, Kazakhstan and Turkmenistan used the system only during training sessions). The GIS Expert expressed the hope that the trainings delivered in late 2020 and during 2021 to most CCA countries, and to be delivered for Master-Trainers in 2022, will facilitate the progress and that ASDC will be used as widely as possible during locust surveys and control operations this year.

16. In response to a question raised by a participant from West Kazakhstan oblast about the possibility to see locust data from neighboring districts of the Russian Federation, the GIS Expert explained that every country has access to CCALM and can display the information for locust surveys from neighboring countries. In addition, the FAO Agricultural Officer/Locust Management underlined that former republics of the Union of Soviet Socialist Republics (USSR), including nine from ten CCA countries, had a standard method of locust survey. Now all data collected in the fields need to be shared to give the possibility to all CCA countries to know the evaluation of the locust situation in nearby territories in real-time. This was the purpose of developing ASDC and CCALM.

How can we improve locust monitoring and ASDC coverage? (mark points) (Item 4)

17. The Agricultural Officer/Locust Management, NSPMD, led a roundtable discussion regarding the problem of decreased locust monitoring in CCA during recession years. He cited as an example the locust monitoring system in the United States of America, which is built on permanent observation points, year after year. For instance, in the state of Wyoming, there are 200 such points of locust survey in the 253 sq km area. This allows to track the dynamics of the locust populations and thus to monitor infestation increases. In this connection, he invited CCA countries to discuss the selection of possible mark points.

18. The Delegate of Georgia underlined that an archive of multiyear locust data is very important for future years; however, he raised the question of the selection of mark points. The Agricultural Officer/Locust Management explained that survey should continue also when the locust situation is calm and that permanent observation points facilitate the continuity of locust survey. The Delegate of Turkmenistan remarked that they had analised all DMA outbreak foci, including 12 historical ones and three newly emerged ones. Regular monitoring in those areas is very important. In addition to what has been said, the Delegate of Georgia informed that they always start surveys from typical CIT habitats. The Delegate of Kazakhstan confirmed that mark points are important. Locations of the historical locust habitats are known on the territory of Kazakhstan, so observations are being carried out in all districts. The Delegate of Azerbaijan noted that locust surveys start from historical locust habitats of DMA in the South and of DMA and CIT in the North-West: there are mandatory points to monitor in every district, which can be considered as mark points. The Agricultural Officer/Locust Management noticed that due to climate change, new DMA sites may appear.

Review of ASDC beta version testing (Item 5)

19. The GIS Expert reminded that ASDC, which was created to facilitate collection and sharing of standardized geo-referenced locust data, includes the geographical coordinates of visited sites, identified with the Global Positioning System (GPS). The ASDC beta-version, released in early 2021, allows to determinate some parameters, such as calculating the surveyed/infested areas or finding the sites surveyed during the previous campaigns. During the 2021 GIS Workshop, Georgia and Russian Federation had agreed to test ASDC beta-version during the campaign held the same year.

20. As a result, the Delegate of Georgia noted an improvement of ASDC functionalities. Among the shortcomings of the application, it was noted that it was impossible to fill the system in the bright sun. Concerning the mobile Internet access, he underlined that 5 GB is enough for one month of ASDC use. The Delegate of Georgia recommended to introduce ASDC beta-version to other CCA countries.

21. The Delegate of the Russian Federation informed that ASDC beta-version is convenient because of the user-friendly template (step-by-step filling of the fields). He also paid attention to the use of ASDC on smartphones and noted a shortcoming, i.e. the inability to see parts of the names due to long field headers. Concerning the tablets, he underlined the difficulty to check photo quality in bright sunlight and to immediately get geographic coordinates without mobile Internet access. A volume of traffic of 5 GB/month fully covers the needs of ASDC for survey. It was proposed that ASDC be better adapted to smartphones.

22. During the discussion, ASDC Developer, ISTT, clarified that all the above shortcomings and comments have already been taken into account during the course of 2021 and that corrections have been made in the new version of ASDC which intended to work with smartphones with a screen size of 5 inches as well. The Delegate of Uzbekistan expressed interest in using the ASDC beta-version in practice. Summarizing the discussions, the FAO International Consultant, GIS Expert, offered to open ASDC beta-version to all CCA countries and to update and complete the user manual accordingly; she also indicated that the new ASDC functionalities would be presented in the forthcoming Training-of-Trainers.

SESSION 2: LOCUST DATA ANALYSIS

Use of the Caucasus and Central Asia Management System (CCALM) to analise locust data (Item 6)

23. The FAO International Consultant, GIS Expert, reminded that CCALM was developed to the benefit of the ten CCA countries to improve data analysis as well as forecast and reporting at the national and regional levels. The main source of data comes from ASDC. CCALM basic functions (data import, query, display, output) and advanced ones (summary, analysis and forecast algorithms) were developed by ISTT in line with FAO technical standards. CCALM is fully available since 2017 in two languages, English and Russian, at ccalm.org and since 2020, in Dari, Azeri, Georgian, Kyrgyz and Uzbek. A progress made in 2021 is that CCALM is now also available in Armenian, Tajik and Turkmen, for a total of ten available languages.

24. In addition to ASDC information, every year, the following data are entered into CCALM: areas infested by locusts; areas infested by locusts exceeding the Economic Threshold (ET); and the treated area for first (oblast/province/region) administrative levels of ten CCA countries and second (district/municipality) ones for Georgia, Kyrgyzstan, Russian Federation and Tajikistan. Some satellite products, such as soil and air temperature, precipitation, Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI) and Normalized Difference Snow Index (NDSI), are also imported into CCALM to improve the analysis of ecological situation and its possible impact on locust infestations.

25. With respect to the system use, the GIS Expert pointed out that every CCA specialist can utilize CCALM, by registering her/himself in the system. However, only the so-called Privileged and Authorized operators have access to the database (at the national level) and can enter data from paper forms and make changes in case of errors in ASDC data. She noted the good progresses made in 2021, with an increase number of total ASDC reports, especially in Georgia.

26. As indicated above, the Russian Federation has developed its own electronic system for plant protection service, including locust data. As in previous year, the linkage between CCALM and such national database continued in 2021. In particular, in the one-year period from 1 October 2020 until 30 September 2021, a total of 27 853 records were imported into CCALM from the locust monitoring system of the Russian Federation, including 26 697 records made during locust surveys and 1156 records with information on anti-locust treatments (ASDC and other records) . ASDC data was also transferred from CCALM to the Rosselkhozcentre database, both for the Russian territory and for nearby countries. In addition, the list of information collected by the Russian national system, in accordance with the ASDC locust survey form, has been expanded to include the following parameters: locust species, locust developmental stage and estimated density per square metre.

27. Concerning Kazakhstan, the same procedure was not possible. Thus, possibilities to ensure automated import data from Kazakh system into CCALM should be further explored; an FAO letter will be needed to facilitate exchanges between the two systems.

28. Following online Refresher courses delivered by FAO to all CCA countries in late 2020 and 2021 and subsequent increase in ASDC use during the 2021 campaign, the GIS Expert could show how such data can allow issuing maps of locust density for a number of countries, i.e. Afghanistan (based on 438 records), Azerbaijan (1600), Georgia (1534), Tajikistan (655) and Uzbekistan (1032).

29. At last, the GIS expert brought attention to historical data of locust-infested areas exceeding the ET, which allow identifying trends and changes at first/second administrative levels during past decade. She suggested to expand such analysis for 20 years as the database now allows to do this. She showed maps on which an increase of infested areas by DMA, CIT or LMI can be observed in CCA region in 2021 compared to a multiannual average level.

30. During the discussion, the Delegate of Georgia underlined again the benefits of CCALM use during locust campaign for making operational decisions for locust control.

Use of satellite products for analysis of locust situation (Item 7)

31. The FAO International Consultant, GIS Expert, noted that CCALM main goal is to improve data analysis and forecasting of locust situation at the national and regional levels, thus contributing to early warning and response. In this connection, ASDC survey data collected during summer/autumn are important. In addition to these data, several satellite products, based on remote sensing data, were introduced in CCALM in 2021, as follows:

    (1) Daily average air temperature and total precipitation from February to September for all CCA countries downloaded from https://www.ftp.ncep.noaa.gov as 20 kilometres grid points. The developed design of legend for air temperature visualization uses blue color for 0/less 0°C and other spectral colors using a 5-degree increment. The legend for precipitation visualization uses yellow-green-blue colors on 5-ml/m2 increment. The period of data storage in CCALM database is two years;

    (2) Soil temperature data for the current day and two days ahead: the temperature is presented as an average value for soil at depths from 0 to 10 cm. Historical soil temperature data is saved in CCALM database every ten days during the period from February until June of the current year;

(3) Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) were received from the MODIS satellite and posted every 16 days in GeoTIFF format on ladsweb.modaps.eosdis.nasa.gov. CCALM database saves NDVI twice every month and NDWI every 10 days. Such data are kept for two years;

(4) Normalized Difference Snow Index (NDSI) is calculated on the basis of data from channel 6 and channel 4 of MODIS satellite with 500 m space resolution. This data are saved every 10 days during the period January-March for all CCA countries.

32. It is assumed that the Training-of-Trainers planned in 2022 will include the use of these satellite products in analyzing climate conditions and corresponding locust situation. For example, analysis of accumulated daily average air temperature and total precipitation during locust season will allow to assess the sequence of hot and dry weather conditions favorable for the increase in the number of locusts. NDSI makes possible to identify areas with a low snow cover and its early melting process; in combination with soil temperature data, it can be used for forecasting locust hatching. On the basis of long-term NDVI data, it is possible to identify areas with a relatively sparse vegetation cover and hot and dry weather conditions, which lead to an increase in the number of locusts. NDWI data allow to analyse water floods in the current and past years in the territories of Uzbekistan, Kazakhstan and the south of the Russian Federation from April to September and to identify the territories under water in areas of intensive egg-laying of the Asian Migratory Locust.

33. During the discussions, the Delegate of Kazakhstan asked why these satellite products exactly (rather than others) were introduced in CCALM. He gave the example when 81 parameters, including soil types and its structure, were used in the analysis to identify areas with favorable conditions for locust habitat in Pavlodar oblast of Kazakhstan. The Agricultural Officer/Locust Management clarified that satellite data for all CCA countries are stored for a period of two years and take up a lot of memory. Because of this, the number of the satellite products used is limited.

34. It was stressed there are no ready-made recipes for using these products to enhance forecasting of locust outbreaks. This will be possible based on development of algorithms and on experience. This year, CCA countries are thus invited to convene a meeting of the E-Committee on CCALM, consisting of GIS specialists and Locust Experts, to develop algorithms for the analysis and interpretation of these satellite products.

Introduction of WEB-CCALM page (Item 8)

35. The FAO International Consultant, GIS Expert, demonstrated a test WEB-page created for the visualization of locust surveys and treatments and satellite products for the ongoing month and located temporarily at: http://ccalm.org/test. It contains elements such as: (1) description/classification of the risk level related to locust infestations in CCA countries; (2) a map showing locust survey and treatments points in all CCA region for the previous months, with a date selection menu; (3) description and demonstration of the products (including satellite ones) used in the system; (4) presentation of the FAO Locust Programme and locust GIS in CCA with link to http://www.fao.org/locusts-cca/bulletins/en/. The Agricultural Officer/Locust Management added that this page will be reviewed and improved and that it will also have to be submitted to FAO relevant services for required clearances before it is published.

Examples of different locust GIS (Item 9)

36. Mr Andrey Pashonin, Programmer from the Russian Federation, presented the digital phytosanitary monitoring system named «Agroexpert». It has been developed to cover more than 2000 harmful organisms, including plant pests and diseases, weeds etc. Information is collected using smartphones/tablets with geolocation and transferred from 76 branches to the central server in Rosselhozcenter. Presently it is used to generate summary reports for the district, region and country.

37. The system is being implemented thanks to theoretical and practical training delivered to staff, mostly in presence and partly online. Starting from 2021, all survey data must be entered into the digital database by using a mobile application. Subsequent quality control of the incoming information is also ensured. Thus in 2021 information was entered for more than 200 000 survey points. The Programmer underlined that the digital phytosanitary monitoring system allows easily and operatively to plan all pest control operations, analise the situation and prepare all necessary materials for Ministry of Agriculture.

Locust treatments: can GIS help to protect environmentally sensitive areas? (Item 10)

38. The Agricultural Officer/Locust Management indicated that FAO pays great attention to environmental protection and human health safety. The third part of ASDC locust control form is devoted to filling in the relevant data. There are many examples in the world when the applied pesticides caused great damage to nature. For example, in Argentina, there has been a massive death of birds. In Europe, cases of of bee mortality are known. That is why in United States of America, for example, GIS is widely applied when locust control operations are planned especially near the specially protected areas or in close proximity to national parks and nature reserves. In this connection, the question of the opportunity to introduce the map of environmental sensitive areas in ASDC was raised for discussion.

39. The Delegate of Kazakhstan noted that it is an actual question. Today, cars/tractors are equipped with GPS devices and operators can more precisely see where they work. In areas close to nature reserves, less toxic insecticides are used.

40. The ASDC Programmer, ISTT, clarified that maps of national parks and specially protected areas (if CCA countries have such electronic maps) can be imported into ASDC in vector form, and that the beta-version allows to see where operators conduct treatments. No decision was however taken at that stage as information on such maps at the country level would need to be collected first.

SESSION 3: LOCUST FORECAST

Locust remote sensing monitoring and early warning, including dynamic monitoring and warning of locust occurrence areas in China (Item 11)

41. Mr Wenjiang Huang, Professor, Aerospace Information Research Institute, Chinese Academy of Sciences, presented the results of locust monitoring and early warning using remote sensing technology based on ground survey data and plant protection model. First study area was selected as Beidagang Reservoir in Tianjin, which is a typical Oriental Migratory Locust habitat with a warm temperate and continental monsoon climate. Indicators for locust area monitoring and forecasting are: (1) host: wetlands and grassland as habitats and reeds, corn and weeds as feeding (these classes

are selected by remote sensing data); (2) climate condition: minimum temperature for egg development is 18°C and for post-embryonic development, above 25°C during 30 days (extracted from Sentinel-3 satellite data); (3) soil characteristics: content of salt is less than 0,5 percent, water content is 8-12 percent in sandy soil, 15-18 percent in loamy soil and 19,22 percent in clay; (4) vegetation cover: between 10-80 percent (classified by multi-temporal remote sensing data). Thus, the locust habitat suitability evaluation is carried out by the classification of above mentioned parameters. The Professor noted that accuracy of identification of the core locust area reaches 90 percent in Beidagang Reservoir in Tianjin and 83 percent in Middle and Lower Reaches of the Yellow River.

42. Concerning the entire China, Prof. Wenjiang Huang noted that a total of 234 counties (city, district) in 12 provinces (municipality, autonomous region) reported Oriental Migratory Locusts during at least one year from 1990 to 2018. These 234 counties, with a total area of 311 423 sq. km, were selected as study area and locust infestation maps of China in 1995, 2005 and 2017 were generated. GIS spatial analysis technologies and remote sensing locust monitoring algorithms were applied. The predicted index of Oriental Migratory Locust occurrence was calculated based on the selected habitat suitability evaluation factors, patch-scale affiliation levels and distribution of potential occurrence areas. The above model applied to forecasting the locust infested area in Tianjin Dagang Reservoir showed an accuracy of 88 percent. This allowed to build the National Locust Remote Sensing Monitoring and Early Warning System which can work at different space levels - from a farm to a multi-province region.

43. At the end of his presentation, Prof. Wenjiang Huang mentioned that his research team combined multi-source Earth Observation data (MODIS and Landsat series in US, Sentinel series in EU), meteorological data, field data, and self-developed models and algorithms for Desert Locust monitoring and forecasting based on the Digital Earth Science Platform. He also expressed the hope to cooperate with CCA countries to test the same approach for locust monitoring.

Use of remote sensing products in Desert Locust forecasting (Item 12)

44. Mr Keith Cressman, Senior Locust Forecasting Officer, NSPMD, presented remote sensing data use in Desert Locust Warning System which covers more than 16 million sq. km, stretching from West Africa to Southwest Asia. He mentioned that the database includes, besides the information collected from the field, many inputs from Earth observation and meteorological satellites as well as locust trajectory and dispersal models. Inside Earth observation and meteorological satellite products, the following can be noted: (1) geo-referenced rainfall estimates are used on a daily, decadal, and monthly basis to estimate the spatial and temporal distribution of rainfall in the desert locust recession area; (2) 250-m-resolution MODIS imagery and its derivatives [NDVI and enhanced vegetation index (EVI)] are used to determine the location of green vegetation in Desert Locust habitats. The images are available every eight days, which is sufficient to detect changes in ecological conditions. It is expected that the system will incorporate 1km/300m Sentinel-3 dynamic greenness map as well; (3) 3km and 1km resolution daily soil moisture maps; (4) daily weather parameters (wind, rain, temperature and atmospheric pressure) with variable resolution. The Senior Locust Forecasting Officer underlined that presently eLocust3m (a simplified version of eLocust3 for mobile phone) and eLocust3g (the same for GPS device) are mostly used for locust survey. All these inputs are processed through the national

(Reconnaissance And Management System of the Environment of Schistocerca - RAMSES) and global (Schistocerca WARning Management System - SWARMS) locust GIS. He also remarked that besides the ground and satellite data and models, experience and terrain knowledge are very important for locust forecasting and early warning.

How to use CCALM to improve locust data analysis and forecast? (Item 13)

45. The FAO International Consultant, GIS Expert, reminded that one of the goals of CCALM development is to improve forecasting of locust situation at the national and regional levels. For this, some of the parameters were already in the database, others were added in 2021 and some are planned to be introduced in 2022. The list of the currently available parameters are as follows:

- During summer locust surveys, data collected in CCALM allow to make forecast for the next season, including: (1) average density of imago per square metre; (2) geographic coordinates of egg laying sites; (3) ascertaining the transitional phase from solitary to gregarious development of locusts; (4) total area with a density of adults above 5 individuals per m^2 at the level of an administrative territorial unit and its increase/decrease in comparison with the previous year.

- During autumn locust surveys, data collected in CCALM allow calculating: (1) average density of egg-pods per square metre; and (2) average number of eggs in an egg-pod.

- At the end of locust season, the locust expert can check the trends, i.e. increase or decrease, of the total infested/treated areas or their ratios.

46. It is envisaged to increase CCALM functionalities. In particular, users will be able to analise daily average air temperature and total precipitation from February to July for all CCA countries (information from open sources of the World Meteorological Organization). This will allow identifying hot and dry weather conditions favorable for the increase in the number of locusts. For this, the following is planned in 2022 :

- Develop a module for calculating the Selyaninov's Hydrothermal Coefficient $HTC=r/(\sum t/10)$ for CCA countries and for a given period of time based on daily air temperature 2 m above ground and total precipitation for 24 hours with customization of display styles and legends in GeoServer;

- Develop a graphical interface for setting parameters for calculation of HTC.

47. Currently, the following satellite products are imported into CCALM:

- Soil temperature data for the current day and two days ahead. Temperature is presented as an average value for soil depths from 0 to 10 cm; these are data combined from satellites, international weather stations and aerostat measurements. These data can be used to forecast the timing of locust hatching.

- NDVI received from MODIS satellite and posted every 16 days on ladsweb.modaps.eosdis.nasa.gov. These data allow to calculate the vegetation conditions index on the basis of long-term NDVI data and give the possibility to identify areas with

relatively sparse vegetation cover and hot and dry weather conditions, which lead to an increase in the number of locusts.

- NDWI received from MODIS satellite and posted every 16 days on ladsweb.modaps.eosdis.nasa.gov. These data allow to analise water floodings in the current and previous years in Uzbekistan, Kazakhstan and the south of the Russian Federation, from April to September, and to identify the areas under water in zones of intensive egg-laying of the Asian Migratory Locust (LMI).

48. In this connection, the following is planned in 2022:

- Develop a module for calculating Integral Vegetation Index (IVI) on the basis of NDVI from the beginning of March until the end of July with setting display styles and legends in GeoServer. Develop a user interface for displaying data;

- Develop a module that allows to identify and highlight water bodies, land and areas, from which water has receded, on the basis of an analysis of changes in water indexes (NDWI) for different dates.

49. It is also envisaged to add the NDSI from MODIS satellite. This will allow users to analise changes in snow cover over the past months.

50. During the discussion, the Agricultural Officer/Locust Management noted that there is a big difference between forecasting of the Desert Locust, which has 2-3 generations per year and univoltine locusts species in CCA. It is important to know where a Desert Locust swarm is flying to (NDVI helps for searching such areas) or where the insects will lay egg-pots (soil moisture imageries used). Concerning CIT/DMA/LMI forecast, the first objective is to know whether the population will increase, remain the same or decrease in the next year. Locust survey data, including morphometric indicators of phases, together with the analysis of weather conditions, will allow to reply to this question. For the latter, a HTC index could be used. To forecast the locust hatching timing, soil moisture and accumulated temperature starting from the day -when it is higher than 10°C - must be analised.

51. The Delegate of Georgia underlined the usefulness of daily average air temperature and total precipitation data and confirmed their use. The Delegate of Kazakhstan underlined that locust itself tells us what it will do during the next year and that it is important to conduct continuous monitoring of the locust habitats even in the years of decrease in locust numbers. The Delegate of Turkmenistan noted the importance of satellite data, especially for arid areas to monitor weather condition and vegetation state. The Delegate of Uzbekistan noted that weather parameters are important for locust situation forecast and that training of Locust Experts is needed for the proper use of CCALM. The Delegate of the Russian Federation also noted the importance of such work indicating that the interpretation of satellite products is not simple. In reply, the Agricultural Officer/Locust Management informed that the E-committee on CCALM will meet during the year and discuss these problems. He also noted that at present, climate change influences strongly locust distribution, especially in temperate latitudes. New locust habitats appear. That is why the accumulation of data over many years and experience in their analysis are very important, especially in terms of transferring knowledge to future generations.

CLOSING

Recommendations for ASDC and CCALM improvement and use in 2022 (Item 14)

52. The recommendations formulated by CCA countries and FAO during the third GIS Workshop, on ASDC and CCALM use and management, are inserted in blue below while the related envisaged actions in 2022 are indicated after each recommendation. They are addressed to countries and to FAO.

ASDC/CCALM use and management:

1) Advocate for introduction and wide use of ASDC and CCALM at the national levels (action: countries and FAO)

Two countries, Turkmenistan and Uzbekistan, have expressed interest for in-depth introduction of CCALM in 2022. →FAO will thus organize two missions of the International Consultant, GIS expert, to these countries.

In addition, it is recommended that countries use ASDC and CCALM for all survey and control operations at the national level, in order to be able to carry out a meaningful analysis and move to effective forecast thanks to CCALM.

2) Designate/confirm at least two information officers with appropriate education and skills who will be responsible for managing CCALM at the national level (action: countries)

At present, Armenia, Georgia and Kyrgyzstan confirmed the list of information officers who are/will be responsible for managing CCALM at the national level → Other countries are requested to send such information to FAO.

3) Continue to provide remote support for ASDC and CCALM maintenance and use, including QGIS, and to deliver related refresher courses/training (action: FAO)

As a continuation of the large effort was made in late 2020 and 2021 (online Refresher courses to all CCA countries to the benefit of 239 experts complemented by national and briefing sessions, delivered by Master-Trainers in Azerbaijan, Georgia, Kyrgyzstan and Tajikistan to the benefit of 365 staff/local manpower), it is planned to organize, in 2022, two regional Training-of-Trainers (TOT), including ASDC and CCALM, one in Central Asia and the other in Caucasus.

4) Create a WhatsApp group including staff responsible for CCALM management and use from the various countries to facilitate direct communication (action: FAO)

Manuals and guidelines

5) Review, update and finalize English and Russian versions of ASDC and CCALM manuals (action: FAO) and translate them into national languages (action: FAO and countries)

ASDC and CCALM manuals still need some improvements in English and Russian, after which they can be translated into national languages → In 2022, manuals should therefore be finalized at least in English and Russian.

6) Ensure the release of video manuals on the use of ASDC, CCALM and QGIS in Russian and English (action: FAO), subsequently with subtitles in national languages (action: FAO and countries)

The video manuals should be released in English and Russian in 2022, as a start.

7) Based on available funding sources, print and dispatch a limited number of Monograph on the Italian Locust to CCA countries and publish the Monograph of Moroccan Locust (action: FAO)

The Monograph on Italian Locust was officially published in January 2022 and funding was identified for print-out of a limited number of copies for all or most CCA countries in 2022. In addition, the Monograph on Moroccan locust is under finalization and will be submitted for approval as official publication in the near future. Once available, it will also be dispatched to all or most CCA countries.

ASDC functionalities

8) Make available ASDC beta version for the 2022 locust campaign and facilitate its use (action: FAO)

ASDC beta-version will be opened for all CCA countries. The user manual will also be updated and completed accordingly and it will be presented to the Masters-Trainers during the envisaged Training-of-Trainers in 2022.

CCALM incrementing and functionalities

9) In order to expand the possibility of creating CCALM products, prepare and enter into CCALM database relevant historical data, starting from 2000 (if available), on: areas infested by locusts; areas infested by locusts exceeding the economic threshold (ET); and treated area; - including for the second administrative level (district)

As a background, the historical data for 2020 -on areas infested by locusts, areas infested by locusts exceeding the economic threshold (ET), and treated area- were inserted into CCALM for all CCA countries. An extension of CCALM products from country/first administrative level (region or province or oblast) to country/second administrative levels (i.e. district, municipality or rayon) was also done for Georgia on the basis of the information received from the country.

In 2021, data at the first administrative level (oblast/province) were also received from all CCA countries. At the second administrative level (district), they were received from Georgia, Kyrgyzstan, the Russian Federation and Tajikistan.

It is thus recommended, with a view to expand CCALM products from country/first administrative level (region or province or oblast) to country/second administrative levels (i.e. district, municipality or rayon), that data be provided by remaining CCA countries, where possible, also at the second administrative level.

9) Translate CCALM interface into national languages

Translation from English or Russian, which had been ensured into Dari, Azeri, Georgian, Kyrgyz and Uzbek in 2020, was further done in Armenian, Tajik and Turkmen in 2021. Only Kazakh is now missing (action: Kazakhstan and FAO).

10) Continue testing of CCALM in national languages (action: users and FAO)

Report will be expected from countries during the next annual GIS Workshop.

11) Improve CCALM functionalities (action: FAO), in particular:

In 2022, the following is planned:

- Develop a module for calculating the Selyaninov's Hydrothermal Coefficient HTC=r/(∑t/10) for CCA countries and for a given period of time based on air temperature 2m above ground and total precipitation for 24 hours with customization of display styles and legends in geoserver; develop a graphical interface for setting parameters for calculation of HTC.
- Develop a module for calculating IVI (Integral Vegetation Index) on the basis of NDVI from the beginning of March until the end of July with setting display styles and legends in geoserver. Develop a user interface for displaying data;
- Develop a module that allows to identify and highlight water bodies, dry land and areas, from which water has receded, on the basis of an analysis of changes in water indexes NDWI for different dates.

The test WEB-page created in 2021 (http://ccalm.org/test) for visualization of locust surveys and treatments for the ongoing month and satellite products will be further improved in 2022 with a view of being published.

12) Pursue cooperation on importing/exporting data from the Russian Federation system into CCALM; Further explore possibilities to ensure automated import data from Kazakhstan into CCALM

The cooperation on importing/exporting data from the Russian Federation system into CCALM will be continued in 2022.→

The possibility to ensure automated import data from Kazakhstan into CCALM will be further explored. An→ FAO letter will be prepared to request and facilitate the process.

Development prospects–

13) Convene the E-Committee on CCALM, including representatives from interested CCA countries and FAO experts (Information Officers), to jointly discuss CCALM GIS products (including interpretation of satellite ones) and expand them(action: FAO and countries)

The E-Committee on CCALM, which was created and first met in July 2021, will be convened again in 2022 to discuss GIS forecasting algorithms. Monthly meetings could be considered or the E-Committee can be called based on needs and possibilities. →

14) Generally, link the management and use of ASDC/CCALM systems to the discussion on long-term regional cooperation (action: countries and FAO)

ASDC and CCALM management should be part of the attribution of an FAO Locust Commission for CCA, a solution which is being explored for sustainable long-term regional cooperation on locusts in the region.

Closing remarks (Item 15)

53. The Delegates of Azerbaijan, Georgia and Tajikistan thanked FAO and expressed readiness in continuing to support the development of CCALM and expansion of its use. The Delegate of Afghanistan also thanked FAO and underlined that GIS use must be practiced. The Delegates of Kazakhstan and Turkmenistan noted that the information received during the Workshop was useful and that they will try to actively support CCALM use. The Delegate of the Russian Federation underlined that such digital systems as ASDC and CCALM for locust monitoring are modern tools representing a big progress in locust management in CCA.

54. The Agricultural Officer/Locust Management, in his concluding remarks, noted that the work was moving in the right direction, with very good progress made since the first and second GIS Workshops held in late 2019 and early 2021. Georgia demonstrated how useful CCALM can be. The main point now, in CCA, is to increase the ASDC cover at the national level. This will in turn allow feeding CCALM and issuing products to analise data and make forecast, thus contributing to early warning and reduction of risks related to locusts.

ANNEXES

Annex 1. List of participants

NAME	TITLE & AFFILIATION	TEL.	E-MAIL ADDRESS	FULL ADDRESS
COUNTRIES				
AFGHANISTAN				
Mr Mohammad Harif YOSUFI	Project stakeholder			
Mr Attaullah HANIF	Project stakeholder			
Mr Najibullah AZIMI	Project stakeholder			
Mr Najibullan OSMANI	Project stakeholder			
Mr Sefatullah AZIZI	Project stakeholder			
Mr Mohammad NASER HAIDERI	Project stakeholder			
ARMENIA				
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Mr Norik BARSEGHYAN	Deputy Director, State Non-Commercial Organization "Service center of veterinarian sanitary and phytosanitary", Ministry of Agriculture			
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Mr David MOSULISHVILI	Inspector, Kakheti regional division, NFA, MEPA			
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Mr Keith Cressman	Senior Agricultural Officer, Forecasting, NSPMD			
Mr Alexandre LATCHININSKY	Agricultural Officer/Locust Management, NSPMD			
Ms Marion CHIRIS	Locust Programme Officer, NSPMD			
Ms Nadiya MURATOVA	FAO Consultant, Geographical Information System (GIS) Expert, NSPMD			
Mr Bahromiddin HUSENOV	Agricultural Officer/Plant Protection/Locusts, NSPMD			
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INTERPRETERS				
Mr Nizomiddin Samshuddinov				
Ms Eleonora Yunusova				

Annex 2. Agenda

WORKSHOP ON LOCUST DATA COLLECTION, ANALYSIS, FORECAST AND REPORTING IN CAUCASUS AND CENTRAL ASIA (CCA)

16-18 February 2022

8 am – 12.30 am Rome time (UTC +1)

PROVISIONAL AGENDA

ITEMS	DOCUMENTS	PRESENTERS	TIMING
Opening			
1. Introduction & Round of presentation	WP	Alexandre Latchininsky, Agricultural Officer (Locust Management), Locusts and Transboundary Plant Pests and Diseases (NSPMD) & Workshop Moderator	**Wednesday 16 February**
2. Adoption of the Agenda	Provisional agenda & timetable	Alexandre Latchininsky, Agricultural Officer (Locust Management)	
Session 1: Locust data collection			
3. Use of the Automated System for Data Collection (ASDC) during the 2021 locust campaign: challenges, solutions, etc.	Working Paper - WP (template)	Countries' presentations	**Wednesday 16 February**
4. How can we improve locust monitoring and ASDC coverage? (mark points)	WP (template)	Alexandre Latchininsky, Agricultural Officer (Locust Management) & Round table/discussions	
5. Review of ASDC beta version testing	WP (template)	Georgia and Russian Federation presentations	

Session 2: Locust data analysis			
6. Use of the Caucasus and Central Asia Management System (CCALM) to analise locust data	-	Nadiya Muratova, GIS Expert, and presentation by one show case country, Georgia	**Thursday 17 February**
7. Use of satellite products for analysis of locust situation	WP	Nadiya Muratova, GIS Expert	
8. Introduction of WEB-CCALM page	-	Nadiya Muratova, GIS Expert	
9. Examples of different locust GIS	WP (template)	Presentations by Russian Federation	
10. Locust treatments: can GIS help to protect environmentally sensitive areas?	-	Round table/discussions	
Session 3: Locust forecast			
11. Locust remote sensing monitoring and early warning, including dynamic monitoring and warning of locust occurrence areas in China	-	Wenjiang Huang, Professor of Aerospace Information Research Institute, Chinese Academy of Sciences	**Thursday 17 February**
12. Use of remote sensing products in Desert Locust forecasting	-	Keith Cressman, Senior Agricultural Officer (Forecast), NSPMD	
13. How to use CCALM to improve locust data analysis and forecast?	-	Alexandre Latchininsky, Agricultural Officer (Locust Management), and Nadiya Muratova, GIS Expert & Round-table discussions	**Friday 18 February**
Closing			
14. Recommendations for ASDC and CCALM improvement and use in 2022	WP	Alexandre Latchininsky, Agricultural Officer (Locust Management), and Nadiya Muratova, GIS Expert	**Friday 18 February**
15. Closing remarks	-	Alexandre Latchininsky, Agricultural Officer (Locust Management)	

Annex 3. Overview on the development, introduction and use of the locust GIS in CCA (2013-2021)

The Geographic Information System (GIS) on locusts in Caucasus and Central Asia (CCA) was developed to the benefit of the ten countries participating in the FAO "Programme to improve national and regional locust management in CCA", under Result 3 of its Roadmap "Locust issues and disasters better anticipated and mitigated" and Activity 3.3 "Develop monitoring and analyzing systems", for use both at the national and regional levels. This was possible thanks to several funding sources over the past years, including projects funded by USAID, the FAO-Turkey Partnership Programme (FTPP), JICA (in chronological order) as well as the FAO Regular Programme.

- **Automated System of Data Collection (ASDC)**

The Automated System of Data Collection (ASDC) was created in 2013 with the objective to facilitate collection and sharing of standardized locust data by Plant Protection/Locust Experts during survey and control operations, using tablets, smartphones and computers. It simulates the FAO standard "Locust Survey Form" and "Spray Monitoring Form" endorsed by CCA countries and serves as a basic data for the locust GIS in CCA, entitled Caucasus and Central Asia Locust Management System (CCALM). After ASDC first testing by Georgia, Uzbekistan and the Russian Federation in 2014-2015, the system was endorsed by CCA countries in October 2015, finalized and made available in eleven languages (Armenian, Azeri, Dari, English, Georgian, Kazakh, Kyrgyz, Russian, Tajik, Turkmen and Uzbek) in 2016/2017.

To support the widespread use of ASDC, FAO delivered or supported the organization of training sessions on ASDC use for a total of 1 282 experts from the ten countries (to various extents) from 2017 to 2021 (including 584 in 2021).[1] During the trainings, recommendations were formulated to improve the functionalities of the system as well as translations into the national languages of individual ASDC fields. FAO also delivered, from 2014 to 2021, 324 tablets (including 133 in 2021) to CCA countries comprising: 43 tablets to Afghanistan, 17 to Armenia, 61 to Azerbaijan, 34 to Georgia, 20 to Kazakhstan (still located in the FAO office), 47 to Kyrgyzstan, one to Russian Federation, 58 to Tajikistan, 15 to Turkmenistan, and 28 to Uzbekistan.

As a result, a gradual increased use of the system in the crop protection services of CCA countries was observed overall. The number of ASDC standardized locust survey and spray monitoring forms increased from 165 records (from 18 users) from five countries in 2016 to 904 records (from 58 users) from seven countries in 2017, 911 records (from 68 ASDC users) from seven CCA countries in 2018, 1,481 records (from 89 users) from seven CCA countries in 2019, 4 285 reports (from 100 users) from eight countries in 2020 and 5 178 reports from eight countries and 73 test reports from the two other countries (from 133 users) in 2021 (as of 30 September).

During the first and second Workshops on Locust Data Analysis, Forecast and Reporting in CCA and the annual Technical Workshops (TW) on Locusts in CCA, held in November 2019, 2020 and 2021, delegates reiterated their interest as well as the need for continued technical and/or operational support (training sessions) for full coverage of the national territory with ASDC.

[1] This includes: 148 experts from eight countries (Afghanistan, Azerbaijan, Armenia, Georgia, Kyrgyzstan, Russian Federation, Tajikistan and Uzbekistan) in 2017; 225 experts from four countries (Afghanistan, Azerbaijan, Kyrgyzstan and Tajikistan) in 2018; 225 experts from nine countries (Afghanistan, Armenia, Azerbaijan, Georgia, Kazakhstan, Russian Federation, Tajikistan, Turkmenistan and Uzbekistan) in 2019; 95 experts from three countries (Azerbaijan, Kazakhstan and Kyrgyzstan) in 2020; and 584 experts from the ten CCA countries in 2021.

- **Caucasus and Central Asia Locust Management system" (CCALM)**

The "Caucasus and Central Asia Locust Management system" (CCALM) was created in 2016/2017 with the objective to improve data analysis as well as forecasting and reporting at the national and regional levels. It is filled using ASDC as well as other sources of satellite products.

More specifically, CCALM basic functions (data import, query, display, output), i.e. the database and its management system, was developed by the Institute of Space Technique and Technologies (ISTT), Almaty, Kazakhstan, and launched in early 2016. Based on the technical specifications worked out and agreed upon by CCA Forecasting and FAO Experts, the advanced functions (summary, analysis and forecast algorithms) were developed by ISTT in line with the technical standards of FAO. They include a set of output products for analyzing Italian (CIT), Moroccan (DMA) and Asian Migratory (LMI) locusts data and elaborating forecasts. Among them, there are maps of: (a) locust densities, (b) treated areas, (c) areas infested (or treated) with densities above the Economic Threshold (ET). CCALM is fully available since March 2017 in two languages, English and Russian, at ccalm.org.

During the 2017-2019 locust campaign, CCALM (basic and advanced functions) was gradually introduced to several CCA countries. In-depth training were delivered to staff from Afghanistan, Armenia, Azerbaijan, Georgia, Kyrgyzstan, Russia and Tajikistan. Two/three experts per country were designated to be responsible for CCALM management and use at the national level. During this testing phase, they made a number of recommendations for improving the system, which were discussed and endorsed by CCA Delegates during the annual Technical Workshop on Locusts in CCA. As already mentioned, two specific Workshops on Locust Data Analysis, Forecast and Reporting in CCA were also held in November 2019 (Tashkent, Uzbekistan) and March 2021 (online). The recommendations formulated at this occasion resulted in a number of improvements of the GIS, including new functionalities.