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Digital and green transformations for sustainable development in the region of the Economic Commission for Europe

Note by the secretariat

This document explores the relations between the ongoing digital and green transformations, in the context of the accelerated pace of digitalization brought about by COVID-19 and the increased awareness of insufficient progress in addressing environmental challenges.

A number of issues are highlighted regarding how the digital transformation can support the green transformation in connection to the work of the Economic Commission for Europe (ECE), in particular as it concerns the management of natural resources and the shift to a circular economy, the impact on sectors that are key for decarbonization and increased efficiency, the potential of innovation and the related measurement issues.

Finally, and to inform the deliberations at the seventieth session of the Commission, the document proposes some lead questions for consideration during the high-level dialogue to help chart a course of action to further promote the digital and green transformations in the ECE region.



I. Twinning the digital and green transformations for sustainable development

A. Digitalization in support of the green transformation

1. **Existing patterns of resource use are exceeding planet boundaries.** Environmental degradation is compromising long-term sustainability and negatively affecting the health of the population. Climate change is no longer a distant risk. It has already materialized in a higher frequency of climate-related extreme events in the ECE region, including exceptionally high temperatures and heavy precipitation. Current tensions in energy markets are pressing the urgency of reducing dependency on fossil fuels.
2. **A green transformation is necessary to change the way in which we produce and consume in order to address climate change, arrest biodiversity losses, and overall reduce environmental pressures.** Commitments to reduce greenhouse gas emissions require a large-scale replacement of existing technologies accompanied by a shift in business practices and consumer behaviours.
3. **The digital transformation can assist in the quest for sustainability while, at the same time, increase prosperity.** It is opening new possibilities for economic development, policy implementation and the management of public services, while altering expectations among consumers and citizens on products and the delivery of services. The COVID-19 pandemic created large-scale disruptions but, as the world grappled to find alternatives to cope with them, it accelerated secular trends in digital technologies. It led to the use of digital services for the first time among some sectors of the population and the mass adoption of technologies for remote working and learning.
4. **While a green transformation is needed to urgently reduce environmental footprints and tackle climate change, the digital transformation is taking place because of the multiple opportunities it opens.** The drivers and the main actors of these two transformations are different. The green transformation reflects a policy push to meet desirable societal goals while the digital transformation is largely a technological process driven by the private sector with multiple ramifications. This difference has implications for the way in which policies and public initiatives can lead, influence or adapt to change.
5. **The pandemic accelerated the growth of the digital economy, increasing social demands and acceptance for digital solutions. But the need to speed up the green transformation is also becoming increasingly apparent.** The Seventh Pan-European Environmental Assessment identified some progress but also persistent negative health impacts of air pollution, increasing net greenhouse emissions, continued problems in the management of transboundary water resources, biodiversity losses, growing waste and other environmental threats.
6. **Digital technologies and green initiatives can be combined in a way that reinforce each other to advance sustainable development.** In a time of multiple crisis, which interact in a way that amplify their consequences, it is imperative to craft responses that generally increase the ability to meet disruptions and increase resilience through integrated thinking.
7. **The contribution of digitalization to the green transformation comes through multiple channels.** They can increase the environmental sustainability of existing technologies. For example, telecommuting has environmental advantages over commuting in fossil-fuel powered vehicles. Digitalization offers new possibilities for natural resource management, through increased efficiency, improved monitoring and tracking, enhanced systems optimization in key activities, and new channels of communication and collaboration with stakeholders. Data-driven innovation holds great promise in tackling environmental challenges and advancing climate change mitigation and the shift to a circular economy.
8. **The acceleration of the green transformation is necessary to reduce the environmental footprint of digital technologies, which have also negative environmental implications.** According to the European Commission, the information and communications technologies (ICT) sector accounts for between 5 to 9 per cent of the world's total electricity

use and more than 2 per cent of all emissions. Substantial amounts of water for cooling purposes are also required in artificial intelligence applications that require large computing power. Data for countries of the Organization for Economic Cooperation and Development (OECD) who are part of the ECE region show that air emissions of fine particulates per unit of added value in high digital intensive industries have not declined in almost any country since 2012, with large differences that are a reflection of the energy mix. A large part of the environmental footprint is accounted for by data centres, cloud services and connectivity.

9. **Expected increases in data traffic will lead to higher emissions if energy efficiency gains and the shift to renewables do not keep pace with the explosion in demand.** In turn, further technological progress can also contribute to reducing the environmental impact of digitalization. For example, the growing deployment of 5G will lower energy costs per data unit and reduce latency (delays in response). This increases the scope of application in areas where rapid reaction is critical.

10. **Other negative environmental consequences come from e-waste, which is the fastest growing domestic waste stream in the world,** according to the Global E-Waste Statistics Partnership, and is expected to roughly double by 2050. Only one fifth of e-waste is being reported as collected and recycled. In addition, the development of e-commerce increases waste related to packaging and higher transport needs.

11. **Recent and projected dynamics stress therefore the need for a twin transformation that is both green and digital.** The multiple negative environmental impacts of digital technologies should be reduced and decarbonization accelerated, while harnessing the potential of digitalization for positive change. Moreover, there may be areas where both transformations tend to exacerbate existing challenges, as they lead to competition for similar resources. Thus, the manufacturing of ICT equipment and related needs, may also increase demand for some critical raw materials that are required for the shift to renewables, electrification and the green transformation.

12. **The green transformation is a source of economic dynamism that offer new development opportunities.** In the European Union (EU), the Joint Research Centre estimates that the green transformation could create almost 900 thousand additional jobs by 2030. However, impacts across sectors, regions and occupational profiles will be different, with some activities being negatively affected. A just transition to a green economy means that benefits are shared widely and that appropriate support, including income protection and reskilling, is provided to those that may be harmed by this wide-ranging transformation.

13. **In the same vein, the digital transformation will reshape jobs and economic activities, thus having a significant impact on labour markets and skills demanded.** New forms of delivery of basic services, including health, banking or education, and access to public information may require some technological skills that would put some population groups with limited or no such skills at a disadvantage. These disruptive impacts may have a detrimental impact on inclusiveness, as services increasingly move online, thus creating barriers for the aged and other groups with digital literacy shortcomings.

14. **While digitalization has a potential divisive impact within countries, existent digitalization divides across countries could also widen and make more persistent development divides across the region.** All these pitfalls call for determined policy action and solidarity across generations and countries to tap into the potential of these twin transformations to advance sustainable development while addressing adverse consequences. In practice, this means that appropriate investment should be mobilised to address related needs, regarding both infrastructure and skills.

15. **The digital transformation introduces a new and changing context for policy action in all areas, including those related to the green transformation.** Related technologies are acting as drivers and enablers of new forms of organisation, innovative business models and changes in lifestyles and social behaviours. Adaptation of policy responses that take into account this evolving reality is thus inevitable.

16. **The next section provides a brief introduction to key technological and policy trends that are shaping the background for the ongoing digital transformation to support the green transformation.**

B. Digital trends

17. **The uptake of basic technologies has spread throughout the region, with rapid increases in the number of internet users, which has been accompanied by a marked narrowing of the differences across countries.** However, the gaps in broadband subscription remain very wide, although far less regarding mobile connections than fixed ones. Differences in access, which also have a gender dimension, are underpinned by the large variability in affordability. Costs as a percentage of income are much higher in programme countries (as much as eight times in some countries), although this is less the case for mobile internet, which helps to explain higher rates of mobile internet take up.

18. **Beyond basic Internet access and computer use, key advanced technologies, such as cloud computing, connected devices and the Internet of Things, artificial intelligence and machine learning or blockchain, are proliferating,** amid falling costs and increased policy and commercial interest. These technologies are often used in combination to enhance their impact. For example, information collected through sensors in the Internet of Things can be transmitted and processed remotely using artificial intelligence to generate new insights, including predictive analytics, that offer new options for resource utilization.

19. **The pace of adoption of different advances technologies varies.** Most OECD countries that are part of the ECE region have displayed a significant increase in the uptake of artificial intelligence (AI) by businesses, although the median value of the share of business with more than 10 employees using AI was only around 8 per cent per cent in 2021. In the rest of the region, this share is likely to be significantly lower. By contrast, the use of the Internet of Things is far more common, in particular in transport and storage.

20. **Countries have embraced digital tools to change the way in which public services are delivered.** The diversity across the region regarding the extent to which public administrations have embraced the digital transformation cannot be fully explained by the variability of internet penetration but reflect also policy choices on the importance attached to e-government and related initiatives.

21. **The digital transformation can not only accelerate the green transformation but also contribute to increased prosperity.** Besides its role as an instrument to promote change in other sectors, ICT services have contributed directly to growth and economic diversification. ICT services exports have boomed in recent years, increasing by a compound annual growth rate of around 14 per cent in 2016–2020 in ECE programme countries and around 8 per cent per cent in the ECE as a whole. The COVID-19 pandemic had a marked effect on trade of digitally-deliverable services. The share of exports of these services over total services, which had been steadily increasing over the last decade, jumped by around 10 percentage points between 2019–2020.

22. **Across the region, policymakers are paying increased attention to the need to support the digital transformation and to shape it in accordance with societal goals.** In many countries, digital transformation is covered by a specific Ministry or integrated in the Ministry of Economy. In the EU, at least 20 per cent per cent of the funding available under the Recovery and Resilience Facility will be dedicated to support the digital transformation, with no less than 37 per cent per cent allocated to the green transformation. Digital-related investment is focused on both infrastructure and digital capabilities, including the deployment of 5G, strengthening digital skills and using digital tools to raise the efficiency of public services. Regional development banks are also increasing financing available for the digital transformation, in addition to the more established focus on the shift to a green economy.

23. **As the global digital economy continues to expand, it becomes critical to bridge existing digital divides, so all countries can participate in the growing opportunities for prosperity that digitalization brings.** At the same time, the digital transformation is also raising new concerns regarding privacy and the use of data, competition, resilience of critical infrastructures and the need to gain protection against cyberthreats. This creates new policy challenges that require effective international cooperation and have to balance conflicting goals.

24. **Improving digital cooperation was identified as one of the action areas by Member States in the Declaration on the commemoration of the seventy-fifth anniversary of the United Nations**, while recognizing the potential of digital technologies to accelerate the implementation of the 2030 Agenda. In his report *Our Common Agenda*, the Secretary-General developed a number of recommendations on this area, where he called for a Global Digital Compact.

25. **The notion of connectivity is closely related to digitalization.** In recent crisis, connectivity has become a channel for the transmissions of shocks. At the same time, the flexibility offered by openness and multiple network connections can add to resilience in the face of adverse circumstances. How to manage connectivity in order to increase resilience and give response to common concerns, while at the same time addressing potential negative implications, remains an important challenge for policymakers in the post-COVID environment that has emerged.

II. ECE and the twin transformations: a short overview

26. **The core work of ECE across its eight subprogrammes - from trade, transport, energy and environment to forests, housing, statistics and economic cooperation and integration— is well aligned with the green transformation and the overall promotion of sustainable development.** Through its normative, policy advisory and capacity-building activities in the region, ECE has been providing impetus to the greening of the economy, advancing decarbonization, increasing resource efficiency and improving the management of natural resources.

27. **At its sixty-ninth session, the Economic Commission for Europe discussed how to accelerate the shift to a circular economy and the sustainable use of natural resources, which is an essential component of the green transformation, and considered ECE work on these areas.**

28. **The digital and green transformations are raising new demands on ECE work, as they modify the context in which the organization operates, overhaul the economic sectors it covers, and alter the way in which it interacts with main stakeholders.** Those are multiple far-reaching changes that affect not only the content of activities but also how they can be performed, including evolving modalities for the engagement of external actors.

29. **The opportunities opened by digitalization to enhance the implementation of its mandates are increasingly being recognized in the work of the organization** across the three dimensions (normative, policy advisory and capacity-building). The digital transformation is expected to have a growing influence in the future activities of ECE, as it raises new demands and expectations that reflect changes in circumstances.

30. **The digital transformation is leading to the migration and adaptation of existing normative outputs to digital formats**, as illustrated by the example of the eTIR system. The computerization of the TIR Convention procedures, which so far relied on paper documentation, will unlock further efficiency gains in reducing cross-border time and costs. Putting digitalization in practice can be complex, as it requires legal and institutional changes. Six contracting parties to the TIR convention have already interconnected their national customs systems with the eTIR international system.

31. **Normative developments are called to play an important role in ensuring that both the digital and green transformation reinforce each other.** This concerns, for example, appropriate guidelines and classifications, information and data sharing or aspects related to the interoperability of solutions. Standards, and more broadly speaking, an appropriate regulatory framework, will be critical to create the appropriate incentives for behaviour changes and to support further international cooperation. ECE normative activities can contribute to meet the needs for standards and guidelines in its mandated areas of work, while adapting them to an increasingly digital world.

32. **Policy advisory work is also reflecting the new realities and opportunities that the ongoing digital transformation is creating for advancing sustainable development.** For example, Environmental Performance Reviews are now including recommendations on

the digitalization of data for the establishment of effective environmental information systems. ECE is also supporting member States in the digitalization of land registries, while taking into account the influence of major trends such as the increased use of artificial intelligence and emerging cybersecurity concerns as they relate to land registration.

33. **The digital transformation is defining new content for technical cooperation and capacity-building activities**, as ECE seeks to assist its member States in meeting changing needs. It is also opening new channels for delivery. For example, ECE has been rapidly increasing its e-learning offer, taking advantage of technological possibilities to reach a broader audience. In 2022, it launched an eLearning platform dedicated to inland transport and trade connectivity – LearnITC – bringing together multiple eLearning courses on the United Nations Inland Transport Legal Instruments as well as the Trade Facilitation Implementation Guide. An eLearning course was developed to raise awareness about air pollution and its effects, ways to prevent and reduce harmful emissions and the Air Convention as an international framework for cooperation on cleaner air. Another online course was prepared on agricultural quality standards and food loss reduction in fresh produce supply chains. An interactive online training course on mainstreaming ageing is also being developed.

34. **The ongoing changes in the context for ECE work will put evolving demands on the organization, creating the need to develop and scale new capacities.** As governments and other stakeholders embrace the digital transformation, it is essential that ECE remains in a position where it can effectively assist them in a world in change that offers new challenges and opportunities. For this, ECE can build on existing system-wide initiatives, such as the United Nations Secretary-General’s Data Strategy. It could contribute to the development of the United Nations system’s Common Blueprint for Digital Transformations, led by the Office of the United Nations Secretary-General’s Envoy for Technology, in areas relevant to the ECE mandate, as a basis for coordinated action within the United Nations system on digital and green transformations. The engagement with these initiatives, the upgrading of capacities and the development of relevant partnerships would support a continued forward-looking orientation in the work of the organisation.

35. **The rest of this document will explore further how the digital transformation can support the green transformation in connection to the work of ECE**, in particular as it concerns the management of natural resources and the shift to a circular economy, the impact on sectors that are key for decarbonization and increased efficiency, the potential of innovation, finance mobilization and the related measurement issues.

36. **More details on relevant products developed by ECE can be found in the companion piece to this document**, entitled “Toolbox of instruments of the Economic Commission for Europe related to digital transformation” (E/ECE/1505). It contains a brief overview of major activities of the Commission’s eight subprogrammes related to the digital transformation and how they relate to the green transformation. Additional information on select ECE instruments that support a green transformation may be found in the toolbox that was elaborated for the sixty-ninth Commission session, entitled “Circular economy and the sustainable use of natural resources: Toolbox of instruments of the Economic Commission for Europe” (E/ECE/1496).

III. Natural resources management and digitalization

37. **Environmental management requires access to timely and accurate data, which provides the foundation for the monitoring of relevant trends and the design of appropriate policies.** Digitalization facilitates collecting environmental information, including more accurate and frequently updated data. The capacity to track better the use of resources helps the enforcement of environmental regulations. In addition, digital technologies make possible more complex analysis to identify trends, carry out simulations and predict future developments, thus contributing to the design of more targeted policy responses.

38. **The Ministerial Declaration of the ninth Environment for Europe Ministerial Conference (November 2022) encouraged the digitalization of environmental**

information systems. Open data, big data and state-of-the art digital technologies can improve data availability, transparency and public involvement in decision making. Digital technologies are playing an important role in increasing and facilitating access to environmental information, including through the transformation of databases, registers, cadasters and other resources with environmental information into digital formats.

39. The **ECE Working Group on Environmental Monitoring and Assessment** is assisting the countries of Eastern Europe, the Caucasus and Central Asia and interested countries of South-Eastern Europe to establish a Shared Environmental Information System (SEIS), including enhancing digitalization. In 2021, a review conducted on SEIS establishment in Europe and Central Asia, confirmed that all member States have, to varying degrees, made progress regarding the establishment of a national system during the past decade and in making environmental information available and accessible online.

40. **Electronic information tools can facilitate public input to and monitoring of decision-making in environmental matters, including by providing publicly documented feedback** on proposed activities, plans, programmes, policies and legally binding instruments. Recommendations on public participation in strategic environmental assessments in the context of the Espoo convention acknowledge the importance of digital tools in this regard. Advances in digital technologies have introduced new possibilities to ensure that sufficient information is made available to the public in a manner that enables consumers to make informed environmental choices.

41. **The Parties of the Aarhus Convention have recognized the importance of modern electronic and information tools to meet the goals of the convention.** They adopted an updated recommendation at its seventh session (October 2021) on the more effective use of these tools. The aim is to make public administration more transparent, accountable, and efficient in providing environmental information, facilitating public participation in decision-making and assisting the public in obtaining access to justice. In pursuing these goals, addressing barriers to access is critical.

42. **Addressing imminent environmental threats requires the communication of information needs in an urgent manner, for which digital tools are invaluable.** Industrial accidents can have severe consequences on human health and the environment, not only within the country they are originating in, but also across borders. It is thus important that neighbouring countries work closely together to effectively respond to such accidents in the event of an emergency. ECE maintains an online Industrial Accident Information System that enables reporting on any accident with transboundary implications. One of the important lessons learned in the context of the COVID-19 pandemic was the need to improve online access to information and its provision upon request in case of emergency situations.

43. **New perspectives in the management of natural resources have been opened by digital technologies and related opportunities in the exchange of information.** ECE has explored how Forest Policy and Management Support Information Systems (FPMSIS) can help to gather forest information, inform decisions, monitor results and, in this way, lead to better policies. Through the InForest platform and complementing national efforts, it has provided an easily accessible and comprehensive source of information with detailed data on forests in the region, including among many other issues, the extent of forest area under independently verified forest management certification schemes.

44. **Advanced technologies such as artificial intelligence, blockchain and machine learning are transforming the way in which resources can be managed, but also the way in which they can be exploited.** Digitalization can be deployed for more precise and efficient resource management, leading to lower water, nutrients or other resource requirements. “Digital mining”, involving the application of increased processing power and artificial intelligence techniques, can optimize procedures for resource evaluation, recovery and management.

45. **ECE has been exploring how the changing technological landscape is affecting the priorities, needs and opportunities for resource management.** The United Nations Resource Management System (UNRMS) is a voluntary global standard for integrated resource management to be used by governments, industry, investors and civil society. As

part of its tools to promote the sustainable and integrated management of natural resources, the UNRMS will include a blockchain and machine learning/artificial intelligence model.

46. **The effective enforcement of policies and regulations for the sustainable management of natural resources is a critical problem.** Digitalization offers improved capabilities for monitoring and control and, in this way, contributes to better enforcement. Illicit, unreported and unregulated fishing is a major threat to marine ecosystems that undermines national efforts for sustainable management of fishing resources. ECE has developed a standard for the exchange of information of the electronic data for fish stock management, covering all phases of fisheries operations.

47. **Assessing the environmental impact of policy decisions is critical to accelerate the green transformation and to mainstream environmental issues in sectoral policies.** Digital technologies offer multiple modelling possibilities. For example, ECE has developed the modelling tool For Future Inland Transport Systems that allows users to explore the impact of different transport policies, including on road, rail and inland waterways on reducing CO₂ emissions and predict future dynamics on the basis of current patterns. In addition, modelling under the Air Convention is part of the activities carried out to assist countries in formulating policy responses to the air pollution challenge. Simulations allows a better understanding of the consequences of different actions and therefore provide a better foundation for sectoral policies that seek to advance the green transformation.

48. **Infrastructure will be affected by climate change, including extreme temperatures, floods, landslides and other events. Digital technologies can be used to contribute to climate change adaptation** by providing tools for the analysis of possible future impacts of climate change on infrastructure, thus assisting countries in planning ahead and taking necessary action early. ECE has developed impact maps that allow the identification of sections of transport networks for which a detailed vulnerability analysis should be carried out to assess their resilience to specific climate change hazards. Impact maps operate in a Geographical Information System Platform and present the potential impact of specific climatic factors, for example precipitation, in particular locations.

49. **In addition to modelling and simulation, digital technologies make possible precise monitoring and tracking of harmful environmental impacts, such as air or water pollution, which is particularly useful given their transboundary dimensions.** ECE has provided guidance on the use of various digital tools, including remote sensing methods, such as satellite and aerial technologies, and modelling to quantify and report methane emissions from coal mines. This is an important issue in tackling climate change, as methane has a warming effect more than 80 times greater than that of carbon dioxide in the short term.

50. **Policies in support of a green transformation can also be enhanced by the ability to engage multiple stakeholders and integrate various data sources.** Harnessing the benefits of open science, citizen science and other similar initiatives for environmental monitoring and protection can offer significant benefits for policy design, thanks to the use of digital technologies.

51. **Technology is at the heart of the digital transformation, but its contribution to the green transformation will not be determined by technological factors alone.** Accepted norms of social behaviour will shape the applicability of technologies and their implications. For example, higher resource efficiency resulting from digitalization does not automatically translate into overall lower resource consumption. As increased efficiency leads to lower price, it may result in higher use, with this rebound effect undermining the positive potential environmental benefits. The implication is that a commitment to sustainability, that is embedded in personal behaviours and social norms, is necessary to take full advantage of the opportunities opened by technology.

52. **Predictions and, more generally, technological possibilities need to be seen in a social and political context, which condition how these will be used.** Predictive analytics associated to artificial intelligence show desirable future courses of action on the basis of past patterns. But, despite the growing trust that it is placed on the insights derived from artificial intelligence, it is clear that pure technological knowledge will not necessarily be translated into action. The unresolved tension between knowing and doing is well exemplified by the still insufficient success in addressing climate change.

53. **These considerations stress the critical importance of education for sustainable development, which increases awareness of critical environmental issues and contributes to behavioural choices that lead to overall lower environmental impacts.** For more than fifteen years, the ECE Strategy for Education for Sustainable Development has contributed to improving learning and education in support of sustainable development. Digital technologies can also be deployed to facilitate advancing these goals.

IV. The shift to a more circular economy and digitalization

54. **Circularity approaches are gaining increasing traction worldwide, being endorsed by both policymakers and businesses as ways to reduce environmental pressures, improving material productivity and strengthen competitiveness.** In a circular economy, resources are reused, remanufactured, recycled or recovered and the generation of waste avoided or minimized, with a life cycle perspective. As an alternative to the “make-use-dispose” model, it aims to close material loops, preserve natural capital and reduce or prevent greenhouse gas emissions.

55. **The shift to a circular economy is therefore an inherent component of the green transformation.** Circularity principles are also relevant to address environmental pressures associated to the digital transformation, in particular regarding the production and use of related equipment.

56. **Tracing materials across value chains is critical for implementing circular solutions that consider the whole life cycle of products. In this regard, digital technologies are essential.** They make possible precise and transparent tracking of materials, while increasing resource efficiency. In particular, blockchain, a particular type of Distributed Ledger Technology (DLT), allows the sharing and updating of information among participants of a network in an open, secure and trusted way. If linked with a system of Internet of Things sensors, it may be used to generate continuously updated information that allows informed decisions on how to manage these materials.

57. **Digital passports can include information to track the origin of products and identify their components** in order to facilitate recycling, the management of waste and the enforcement of the responsibilities of producers, while enabling consumers to make informed environmental choices. Tracing materials across value chains is critical for implementing circular solutions that consider the whole life cycle of products.

58. **Beyond circularity, tracking and traceability are critical for the implementation of environmental or social standards.** A Supply Chain Traceability Information Exchange Standard based on blockchain, created by ECE, allows traceability across the value chain in the garment and footwear sector. A related pilot project for cotton and leather is being implemented in collaboration with industry actors such as brands, garment manufacturers, and certification bodies in a blockchain environment. With a broader sectoral remit, the ECE Team of Specialists on Environmental, Social and Governance Traceability of Sustainable Value Chains in the Circular Economy, is exploring solutions to advance circularity in other critical sectors, such as critical raw minerals, including with the use of advanced technologies.

59. **As blockchain can deliver transparent and uncontested records, it can be used to create certificates of origin in different areas.** ECE has been mandated to assist in the development of these certificates in critical areas related to the green transformation, including the Guarantees of Origin for Hydrogen and the Renewable Energy Certificate, to enhance trust and facilitate trading, thus contributing to the development of non-fossil fuels. Reliance on renewable energy is seen as a necessary component of the shift to a circular economy. ECE is currently exploring policy perspectives regarding the use of digital certificates of origin based on blockchain.

V. Driving transformation in key sectors

60. **The green transformation requires a revamped infrastructure, together with improved management, in order to support decarbonization and reduce the environmental footprint of key economic sectors.** Digitalization opens new ways to design and operate infrastructure and related elements and services in different sectors, leading to higher efficiency and lower use of resources, though improved monitoring, data collection and analysis. Exploiting this potential requires the capacity to collect and use available data for decision-making, including through the development of harmonized and integrated data management systems related to infrastructure, which can inform planning and management.

61. **The decarbonization of the energy sector, the shift to sustainable mobility and the reshaping of urban services and the built environment to advance the green transformation is supported by the ongoing digital transformation, which is also creating new regulatory demands.**

A. Fostering the energy transition

62. **The transformation of the energy sector, which is the largest source of greenhouse gases emissions, is critical for climate change mitigation and the greening of the economy.** Increasing both the share of renewables in the energy mix and energy efficiency is necessary to reduce overall environmental footprint while enhancing energy security. Digitalization can contribute to this transformation by facilitating the optimization of energy systems, the use of large datasets for planning purposes and the emergence of new business models bringing together decentralized producers, consumers of energy and “prosumers”. ECE has been exploring the role of digitalization and the increased use of big data and geo-spatial data in the provision of energy services in the context of its work on sustainable energy.

63. **The shift to renewable energy implies also changes on how an increasingly more decentralized energy system is being managed.** Smart grids, which allow for improved monitoring and control of power flows, rely on the use of digital technologies to facilitate the balancing of supply and demand. Consumers who generate renewable energy can also be sellers to the grid (“prosumers”).

64. **The development of renewable energy requires significant infrastructure upgrading and will increase the demand for critical raw materials, which are also necessary for electric vehicles and digital equipment.** The application of circular principles in meeting this demand would reduce the need for resources. Digital technologies can be used for traceability of materials and for bringing together stakeholders across the lifecycle of products, thus facilitating circular approaches. ECE has elaborated multiple tools to support its member States in their efforts to secure a resilient, sustainable and ethical supply of critical raw materials for the transition to a net-zero economy.

B. Sustainable mobility and the digital transformation

65. **The integrated management of transport systems can facilitate decarbonization while increasing consumer choices.** Multimodal travel and cargo digital platforms can combine various modes of public transport with walking and cycling, while ensuring a more accurate and real-time measurement of demand. Digitalization of integrated urban transportation infrastructure systems can reduce public transportation wait times or limit vehicle idling, thus resulting in increased efficiency and reduced resource consumption.

66. **“Digital twins” help to analyse options regarding the carriage of freight,** regarding for example, booking of containers or bundling of transport journeys. In this way, they facilitate the identification of efficiencies, leading to operational advantages, cutting costs and reducing environmental and societal impacts.

67. **Modern vehicles generate vast amount of data.** According to McKinsey, connected cars produce around 25 gigabytes of data every hour, providing information on multiple

aspects, including route or road conditions. These details can feed into analytics providing a foundation for innovative mobility-related business models and for repair and maintenance services.

68. **ECE is shaping the regulatory framework for inland transport in line with these technological and social developments.** It is leading the normative work on automated and connected vehicles, which is a critical area for the future of mobility. It has elaborated regulations and technical provisions on multiple related areas, such as cybersecurity, software updates and data storage, among others. A new legal instrument on the use of automated vehicles in traffic has been mandated.

69. **This process of adaptation and development of normative outputs will continue in the years ahead.** The “Inland Transport Committee Strategy until 2030” aims to ensure that its regulatory functions are keeping pace with cutting-edge technologies driving transport innovation, especially in the areas of Intelligent Transport Systems, autonomous vehicles and digitalization. The ultimate goals, which will serve to advance the green transformation, are improving traffic safety, environmental performance, energy efficiency, security and efficient service provision.

C. Smart cities and the built environment

70. **As around three quarters of global carbon emissions take place in cities, solutions implemented at the local level could be a major driver for global climate mitigation efforts.** Globally, buildings account for around one third of total final energy consumption and, in the EU, for 12 per cent of greenhouse gas emissions. The increased use of sensors and other devices in the Internet of Things means that buildings generate growing amounts of data, which can be used to take more informed decisions. According to the ECE Task Force on Digitalization in Energy, these technologies could save 10 per cent of total energy consumption from the buildings sector by 2050.

71. **Developing buildings that are environmentally more sustainable and also more resilient to the impacts of climate change requires appropriate consideration of multiple factors.** Digital tools, including modelling and AI-based predictive analytics, can assist in both the design and management of buildings. A digital representation of a building facilitates the collaboration among multiple stakeholders and the adoption of circular solutions based on lifecycle analysis. Geographic position systems (GIS) can be used to optimize the position of buildings.

72. **However, buildings have long lives and therefore the process of replacement by modern and more efficient housing stock will proceed only slowly.** In the short term, renovation and retrofitting can make a significant difference, with digitalization contributing to increase energy efficiency through better management. While digital technologies can be used at any stage of the lifecycle of a building, ECE work on buildings and energy efficiency has stressed that that appropriate regulation, including through technical standards, needs to be in place so that the right incentives are created, and technological possibilities are translated into actual action.

73. **Smart cities rely on digital technologies to optimize the delivery of public services, improve the management of natural resources, reduce pollution and traffic congestion and lower the environmental footprint of buildings.** ECE is part of the initiative United for Smart Sustainable Cities, a global platform that advocates for public policies that support the transition to smart cities. Together with the International Telecommunication Union (ITU), it developed a set of Key Performance Indicators (KPI), which have been refined to better reflect Sustainable Development Goals (SDGs). These KPI have been used to evaluate 14 cities so far.

VI. Facilitating exchanges across borders: a new drive for increased efficiency

74. **Trade can contribute to the green transformation by making possible the exchange of critical goods and services, enhancing resilience through diversified supply chains and widening the opportunities for economic collaboration.** Efficiency gains can be increased further by the digitalization of trade documents, which reduces time and other resource needs and diminishes the scope for errors.

75. **Internationally recognized standards greatly facilitate exchanges among the different partners involved in commercial transactions.** The United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) has been working for more than 50 years in developing and maintaining such standards. The expansion of e-commerce has made its activities even more relevant, leading to increased volumes of data exchanged and the potential increase in the number of parties involved.

76. **UN/CEFACT manages around 500 standards, with some of them having a direct relevance for the green transformation and the shift to a circular economy.** These include among others, the e-Basel standard, which concern the tracking of waste movements, as required by the Basel Convention, the e-CERT, an electronic sanitary and phytosanitary certificate or the eCITES, which simplifies and automates trade procedures to facilitate the enforcement of the Convention on International Trade in Endangered Species of Wild Fauna and Flora.

77. **Despite the benefits offered by the digitalization of trade documents, there still remains an untapped potential.** The ECE Regional Report 2021 on Digital and Sustainable Trade Facilitation concluded, after surveying available evidence, that the current low rates of digital trade facilitation measures call for greater attention to this issue.

78. **Transport activities, which underpin the movements of goods across borders, are framed by a set of ECE administered conventions, which are being adapted and developed to take advantage of the opportunities created by digitalization.** The so-called eTIR project, which aimed at the paperless operation of the TIR Convention, was launched already in 2003. Another example is the Additional Protocol for the International Carriage of Goods by Road (CMR) concerning the electronic consignment note, which was open for signature and ratification in 2008. The eCMR procedure is currently being operationalized and a new electronic application developed. With more than 1 billion paper CMR issued annually worldwide, the potential savings are considerable.

79. **The digitalization of data and document exchanges in multimodal transport and trade, establishing digital corridors that allow for seamless exchange of information, is a complex task.** ECE has developed standards that provide solutions for interoperability of the data of the multiple documents accompanying goods transported by maritime, road, railway, air and inland water transport.

VII. Digitally-enabled innovation and the green transformation

80. **The green transformation, which will decouple economic growth from the use of resources, will need new ways of producing and consuming.** Innovation, including not only technological change but also new organizational practices and business models, is the ultimate driver of sustained and sustainable increases in prosperity. Innovation will be an enabler and accelerator of the green transformation, which, through policy incentives and guidance, is encouraging innovative behaviours. A dramatic example is the falling cost of renewable energy, with solar declining by a compound annual growth rate of 17.3 per cent in 2010–2020, according to the World Intellectual Property Organization (WIPO), as a result of technological progress.

81. **Fostering innovation, aligning it with the needs of the green transformation and using the potential of digitalization to advance both goals are critical policy issues on the way to sustainable development.** Ultimately, the scale of the changes required in production and consumption patterns demands a transformative innovation, which will need

to be accompanied by new models of innovation governance as well. Digitalization is key for business innovation and the transformation of public services, including regarding critical areas for the green transformation, such as e-mobility, smart grids, the circular economy and many others.

82. **ECE supports its member States in designing effective innovation policies, bringing systemic considerations that look at the interrelations between different components of the innovation system and seeking to improve overall innovation performance while pursuing societal goals.** It is engaged in the promotion of transformative innovation across the region and provided country-specific policy recommendations based on extensive research to member States in Eastern Europe, the Caucasus and Central Asia. The promotion of high-technology entrepreneurship, linked to the use of digital technologies, has often been a goal of innovation policies in these countries. ECE developed a handbook on business incubators for sustainable development seeking to assist the countries of the United Nations Special Programme for the Economies of Central Asia (SPECA) in these efforts.

83. **Innovation involves also new models of consumption.** In a sharing economy what is not being used can be rented out through direct interaction between the parties, thus increasing asset utilization and the life in use of objects. Most often, this consumption model is underpinned by digital platforms that reduce transaction and information discovery costs and thus facilitate exchanges. The use of unexploited capacity can serve to meet consumption demands without putting additional pressure on resources, while, at the same time, providing complementary income sources.

84. **Multiple economic sectors have experienced a rapid growth in the use of digital platforms in recent years, as these platforms gain increased acceptance among consumers and make possible new business models.** ECE has been exploring the use of these platforms in different areas of activity. As part of its work on innovation, it has drawn attention to the role of entrepreneurship as the dynamic force to take advantage of the possibilities opened by digital platforms.

85. **Car-sharing and carpooling, which ensure access to the use of a car without individual ownership, most often rely on digital platforms.** These models bring many potential benefits, including reduction in fuel consumption, distance travelled, and the number of personal vehicles, with obvious positive environmental and health implications. ECE has been working on digital keys, which can facilitate further car-sharing. The integration of shared mobility initiatives in cities sustainable urban mobility plans that aim to reduce congestion and pollution has been discussed at ECE as part of the work of the Transport, Health and Environment Pan European Programme (THE PEP) and other activities around the concept of mobility-as-a-service.

86. **The development of the sharing economy in housing markets, with the rapid spread of very short-term rental activity, is linked to the emergence of digital platforms which have facilitated the exchange of residential space.** This emergent phenomenon, which has multiple ramifications, has been documented and studied by ECE in a comprehensive publication released in late 2022. While the sharing of assets contributes in principle to circularity and better use of resources, these practices may have a negative impact on the affordability of long-term rentals, as businesses rather than private individuals become the drivers of these short-term rentals. This has prompted the need to consider appropriate regulation to address undesirable effects associated to this growing practice.

87. **Innovative business models which can contribute to the green transformation, such as the provision of energy-as-a-service or mobility-as-a-service, have been made possible by the use of digital technologies.** Such models, which have been considered in the work of ECE, facilitate integrated approaches and solutions, while incorporating efficiency considerations, simplifying comparisons among providers by consumers and, if public actors are involved, introducing explicit social goals. Integrating various providers in a unique platform raises challenges, in particular regarding revenue sharing, but the data generated by users offers useful insights to further improve service provision.

VIII. Mobilizing finance

88. **Revamping infrastructure to advance the green transformation and putting in place the foundations for the continued expansion of digitalization requires appropriate financing.** In particular, high-quality broadband coverage across the region remains unequal. Increasing coverage may require the collaboration between the public and private sectors through the use of public-private partnerships. Interest in this collaboration has increased with the COVID-19 pandemic, which underlined the importance of connectivity for all communities as a foundation to meet other policy goals.

89. **ECE promotes a Public-Private Partnership model that seeks to ensure that collaboration between both sectors is structured and governed in a way that results in an effective contribution to meeting the SDGs.** A detailed evaluation methodology has been developed to score projects against specific criteria to assess this contribution, including regarding greenhouse gas emissions, waste, water use and other environmental indicators related to the green transformation.

90. **Bringing together key stakeholders from public and private sectors is critical to catalyse additional private sector investment in climate mitigation and adaptation in line with the SDGs.** ECE has sought to provide effective platforms that bring together various stakeholders to facilitate a dialogue on necessary actions to mobilize finance and to share information on concrete investment projects. Ahead of COP 27, it held a Regional Forum on Climate Initiatives to Finance Climate Action and the SDGs. At the Forum, various investment-ready projects were presented, including regarding digital infrastructure and systems to address climate change and support the green transformation.

91. **New forms of collaboration, which are based on the pooling of information, depend on digital technologies.** ECE, with the support of other partners, plans to launch an International Transport Infrastructure Observatory (ITIO) based on a Geographic Information System (GIS) platform. The ITIO will provide an innovative tool to finance transport infrastructure, offering an electronic marketplace between multilateral development banks and governments, who can upload their projects. Additional relevant information can be layered, including on the impact of climate change and the accession to United Nations conventions. In addition, other organizations can upload various types of information, which will facilitate cooperation among different infrastructure initiatives.

IX. Measuring the transformations

92. **Collecting, sharing and improving the use of data, thus leading to better policies, is critical to address a wide range of sustainable development challenges.** In particular, steering the twin digital and green transformations to advance sustainable development goals requires having in place a monitoring framework that measures progress towards a green economy while tracking both the positive and negative impacts of digitalization. Capturing information on new technologies and the risks and opportunities they pose raises significant conceptual and coordination challenges, given the scale and the speed of change.

93. **National statistical offices are adapting their infrastructures to these new challenges, which also offer new opportunities for data collection.** Some of the new sources include social media platforms, satellite imagery, administrative data, and information collected through online apps, among many others. While these new approaches can help to obtain more updated information, they also raise issues regarding privacy and data acquisition.

94. **ECE, in the context of the work of the Conference of European Statisticians and the ECE High-level Group on Modernization of Official Statistics, has supported a reflection on these issues, collated experiences and provided guidance that can help member States to address these questions.** For example, a recent publication presented different applications of machine learning within statistical organization and key considerations regarding its use.

X. The road ahead: Some policy issues for discussion

95. As outlined above, ECE has been harnessing the power of digitalization to advance the green transformation in multiple areas of its work. The context for its activities will continue to evolve under the impact of technological change and new demands will emerge to further support the necessary acceleration of the green transformation. A high-level policy dialogue could explore opportunities and lingering challenges that need to be addressed to facilitate further progress in twinning the green and digital transformation. This may include the identification of focus areas for future work within the multi-sectoral mandate of ECE and opportunities for closer collaboration with other actors. Discussions could consider the following questions:

(a) How can the digital and green transformations be advanced in a way that supports more inclusive, prosperous, circular and greener economies? What are the key drivers and impediments in moving in this direction? What is the role of international cooperation in enhancing these positive impacts? How can required resources be mustered?

(b) How should regulations and other normative work adapt and evolve to the new context defined by the digital transformation? How can they contribute to harness the potential of digitalization to advance the green transformation? What are the implications for ECE work?

(c) How can partnerships be developed to advance digital and green transformations? What are the new types of partnerships that digitalization is making possible?
