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SIXTH ASSESSMENT REPORT (AR6) PRODUCTS

Outline of the Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems

(Prepared by the Scientific Steering Committee for the Scoping of the Special Report)

(Submitted by the Secretary of the IPCC)

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8. ANNOTATED OUTLINE OF CHAPTERS

This section provides additional information on the Special Report outline, based on expert discussions reported throughout the Scoping Meeting, and particularly those discussions emerging during BOG III and the final plenary. The annotations are based on input material from the chairs and rapporteurs of BOG III groups lightly edited by the WG III TSU for consistency. The annotated material has been sent to the Scientific Steering Committee for comment. The annotations have not been sent to all attendees at the Scoping Meeting and may therefore not reflect the views of all participants.

Chapter 1: Framing and context (~15 pages)

Input from Anita Wreford and Jean-Francois Soussana

- Socio-economic, biogeochemical, and biophysical interactions between climate change and desertification, land degradation, food security and GHG fluxes
- Land as a finite resource under climate change, current and additional demands
- The contribution of this report in relation to reports by IPCC and other relevant institutions
- Key concepts and definitions
- Treatment of uncertainties
- Integrated storyline of report, chapter narrative, sequence, linkages

Chapter 1 will frame the Special Report introducing key concepts and issues, identifying challenges related to the five elements of the report and interactions between the different elements.

The first bullet is intended to address interactions between the use and management of land resources (including, where appropriate, water resources). The assessment of interactions might include: drivers, impacts, associated climate feedbacks (e.g. GHG fluxes, albedo, aerosols); land climate dynamics and interactions including long-term climate change, climatic variability, the role of climate extremes and how they interact with land (e.g. degradation, land cover, implications for water fluxes; mutual linkages among drivers of land degradation-desertification, sustainable management, food security, climate change and policy responses). Also discussed were interactions between adaptation and mitigation; and implications for land use.

The second bullet is intended to address the additional and competing demands for land and the associated environmental pressures under climate change. This could include competition for land use due to socio-economic drivers providing incentives for land-use

change (e.g. population growth; changing market prices due to a range of factors including climate change impacts), impacts of land use change on adaptation and mitigation potentials and, conversely, implications of adaptation and mitigation responses (for instance bio-energy) on food and nutrition security and climate.

The third bullet signals that other related reports (for instance AR5, IPBES, FAO, UNCCCD, SR1.5, SROCC) are relevant. The broader policy context and ways of informing the implementation of the Paris Agreement might also be considered.

The fourth bullet indicates that key concepts and definitions may need to be introduced in order to help the reader; this would require careful cross-checking with the authors of the other chapters of the Special Report and ensure consistency. Examples of definitions that it may be appropriate to include are for instance: spatial scale (e.g. regions, biomes) and temporal scales (as related to land and climate processes).

The fifth bullet recognises that the treatment of uncertainties will require consideration in this report, within the framework of the overall IPCC uncertainty guidance. Limits to knowledge, for example uncertainties in observing systems and limitations to ability to measure change, e.g. soil observations could be discussed.

Finally, the chapter will require an outline of the narrative for the Special Report and an explanation of the logic of the proposed flow of chapters and their interlinkages.

Chapter 2: Land–climate interactions (~50 pages)

Input from Jo House, Roberto Sanchez Rodriguez and Elena Shevliakova

- Climate change and variability that influence desertification, land degradation, food security, sustainable land management and greenhouse gas (GHG) fluxes in terrestrial ecosystems
- Terrestrial GHG fluxes and related stocks: methods, status, trends, projections, and drivers
- Biophysical and non-GHG feedbacks and forcings on climate
- Consequences for the climate system of land-based adaptation and mitigation options, including negative emissions

The first bullet covers a brief updated global assessment of past and projected changes in climate trends and variability, including extremes, which are pertinent to terrestrial ecosystems. This would build on AR5 to include updates in the literature.

Regional information critical to understanding the impacts on key biophysical and socio-ecological processes for the specific areas of interest to this report (including the identification of hot spot regions) might also be considered here. It is anticipated that this information will provide background and context for more detailed explanations in chapters 3, 4 and 5.

The second bullet addresses GHG fluxes and related stocks in both managed and unmanaged terrestrial ecosystems including the status, trends and projections of GHG fluxes with updates since AR5. Also in scope are the methodologies for Measuring,

Reporting and Verification of greenhouse gas fluxes and the importance of enhancing transparency in understanding and interpretation of GHG flux estimates.

This bullet includes drivers of changes in GHG fluxes including the interlinkages between socio-economic, political, cultural, ecological and biophysical processes. There is likely to be a focus on GHG fluxes related to desertification, degradation and food security with linkages to be expanded upon in other chapters of the report. Areas of new process understanding, including feedbacks such as CO_2 fertilisation, acclimation, water and nutrient limitation and soil processes may be considered in scope.

The third bullet focusses on the land-based, biophysical and other non-GHG feedbacks and climate forcings related to land use and land cover changes that will be an important aspect of this chapter. This could i hydrological processes (e.g. soil moisture limitation, irrigation), land surface characteristics (e.g. albedo and roughness), and aerosols (e.g. dust).

The final bullet addresses the consequential climate implications of current and projected land-based mitigation and adaption options. It explores the multiple dimensions of land – climate interactions for specific areas of interest such as afforestation, negative emissions in the land sector, and the contribution of land to achieving net zero emissions, including potential socioeconomic, political and ethical dimensions.

Chapter 3: Desertification (~35 - 40 pages)

Input from Victor Castillo and Alisher Mirzabaev

- The specific nature of desertification
- Status, current trends and future projections of desertification linked to climate change, globally and regionally
- Climatic and anthropogenic direct and indirect drivers of desertification
- Attribution: distinguishing between climatic- and human-induced changes
- Desertification feedbacks to climate, including sand and dust storms
- Climate-desertification interactions, including past observations and future projections
- Impacts of desertification on natural and human systems in a changing climate
- Technological, socio-economic and policy responses to desertification under a changing climate, including economic diversification, enabling conditions, co-benefits
- Hotspots and case-studies

The first bullet addresses the specific characteristics of desertification as affected by climate change. Desertification is a type of land degradation of drylands, therefore it is anticipated that Chapter 3 and Chapter 4 will be closely interrelated. Characteristics relevant to discuss could include water scarcity, high temporal climate variability, exposure to extremely hot temperatures, concentrations of poverty, importance of pastoral livelihoods and tipping points which may substantially affect desertification. The challenges of implementing measures to avoid, reduce or reverse desertification, through restoration and rehabilitation are also relevant.

The second bullet considers future projections of desertification and could involve the evaluation of different models/scenarios used for these projections including global and

regional scale analyses. For some areas climate change may, for instance, may be considered to have positive impacts regarding land use / land productivity.

The third bullet addresses climatic and human drivers of desertification, both direct and indirect. Examples of direct climatic drivers could include changes in mean and extreme temperatures, increases in CO_2. precipitation, wind, as well as in sand and dust storms. Indirect climatic drivers could include soil erosion, salinization and loss of vegetation. It was considered important to maintain a strong focus on climate change and it is anticipated that the discussion on human drivers of desertification would be on those that may also be affected by climate change. It will be necessary to ensure the discussion complements and is consistent with Chapter 4.

The fourth bullet reflects debate about available evidence for distinguishing between climatic and human drivers of desertification including their relative roles in causing or reversing desertification. Given the context-specific nature of these interactions, a regional focus or specific examples may be warranted.

The fifth bullet considers the feedbacks of desertification on climatic change. Processes identified that it may be relevant to consider include sand and dust storms, aerosols, changes in surface albedo, and loss of carbon sinks.

The sixth bullet builds on the previous one and considers how climate change interacts with desertification and the role of past observations and future projections. This may include discussion of past climate change and desertification inter-linkages from paleo-climatic records. Global and regional scale analyses could provide a potential resource for this analysis. How climate change scenarios inform projections of desertification could also be discussed.

The seventh bullet focusses on feedback effects of desertification on natural and human systems. This could include impacts on ecosystems, including impacts on water, soil and soil carbon, vegetation cover, biodiversity, aerosols and dusts, and impacts on socio-ecological systems (for example, impacts on poverty, migration, food security and livelihoods). Desertification-induced land use and land cover changes under climate change and their impacts on GHG fluxes may also be relevant. This bullet has significance for other chapters, notably Chapter 4 on land degradation and Chapter 5 on food security.

The eighth bullet point addresses responses to desertification under a changing climate including the potential impact of global mitigation efforts on dry lands and potential boundary conditions for responses to desertification under climatic changes. The chapter might cover the potential and limits for both adaptation and mitigation responses, and their co-benefits. Responses may include technological, socio-economic and policy actions. Sustainable land management may be discussed in the context of technologies and land use practices, land use change, land restoration and land rehabilitation, protection of natural areas, water management, and livestock management. Socio-economic responses could also be pertinent, for example, economic diversification and mobility. Policy responses and enabling policy frameworks involving, for example, institutional frameworks relating to the security of property and land tenure, may also be relevant.

The ninth bullet identifies that it may be appropriate to highlight case studies and hotspots where climate change affects desertification and hotspots of situations where desertification affects regional climate. Such case studies may also identify effective response options.

Chapter 4: Land degradation (~40 pages)

Input from Mariam Akhtar-Schuster and Ian Noble

- Processes that lead to degradation and their biophysical, socio-economic, and cultural drivers across multiple temporal and spatial scales
- Linkages and feedbacks between land degradation and climate change, and their effects on ecosystems and livelihoods
- Status, current trends and future projections of land degradation linked to climate change, globally and regionally
- Attribution: distinguishing between climatic- and human-induced changes
- Direct and indirect impacts of climate change on land degradation, land degradation on climate change, and reactive and proactive response options for key socio-ecological systems
- Impacts of land degradation on natural and human systems in a changing climate
- Integrated higher-level responses, e.g. sustainable land management (SLM) (where possible related to the sutainable development goals (SDGs), including considerations of cost, incentives and barriers
- Hotspots and case studies

Although the chapter title refers to an adverse change, it is anticipated that the chapter will discuss situations, processes and drivers which lead to both degradation and improvement of land. Reactive and proactive response options to combat land degradation in the context of climate change are expected to be an important component. This discussion is also relevant to a number of the Sustainable Development Goals (SDG). It should be noted that there are strong interrelationships between Chapter 3 and Chapter 4. The discussion of Land Degradation will also need to be consistent with the definitions provided in Chapter 1.

The first bullet focusses on the current understanding of processes that lead to land degradation (other than those discussed in Chapter 3) and the responses and options which can be deployed to address degradation. This could include a detailed exploration of processes which relate to climate change and consideration of processes that specifically lead to degradation and their drivers (e.g., soil-water-vegetation interactions, and social, economic and cultural drivers operating at multiple temporal and spatial scales). Other international bodies including UNCCD/SPI, IPBES, and the UNEP International Resources Panel have produced a body of relevant and complementary literature.

The second bullet explores linkages between climate change and land degradation including their effects on livelihoods and implications for sustainable land management (SLM). Both managed and natural (unmanaged) land, and associated ecosystem services and ecosystem functions, are in scope. Distinctions between managed and unmanaged land provides important reference points for the attribution of change.

The third bullet extends the discussion to include both global and regional scale analyses exploring how climate change scenarios inform projections of land degradation.

The fourth bullet addresses evidence and approaches for distinguishing between climatic- and human-induced change. The chapter may discuss resilience and tipping points in landscapes, in the context of climate projections. The chapter may also discuss means to monitor land degradation in the light of climate change.

The fifth bullet focusses on cause and effect relationships and processes and how these may relate to each other within a global framework of land degradation, and within the context of specific socio-ecological systems (e.g. forested land, wetlands, croplands, urban lands, rangelands and including landscape mosaics). Response options and effects could also be considered (e.g. land use change, land conversion and reversion).

The sixth bullet focusses on feedback effects of land degradation on natural and human systems. The evaluation of observed and projected impacts might include direct and indirect impacts of climate change on land use and cover; changes/loss in biodiversity and habitats; changes in land productivity or function, and associated processes affecting ecosystem services and livelihoods. Examples of direct impacts might include drying and droughts (with due regard to Chapter 3), phenological response to gradual changes in climate parameters, extreme events, variability and irregularity in monsoon cycles, and impacts on water resources. Examples of indirect impacts might include increased and changed seasonality of wildfires, and chronic stress on humans and ecosystems.

The seventh bullet focusses on direct and indirect changes in radiative forcing caused by land use and land cover change. Direct changes in radiative forcers might include losses of carbon stocks and change in land surface albedo. Indirect changes in radiative forcers might include expansion of cropping and grazing lands into forests. The chapter may also consider feedbacks of land degradation, and land management more generally, on climate, including discussion of possible adaptation and mitigation actions. Reactive and proactive response options including avoiding, reducing and reversing land degradation and their associated synergies and trade-offs in the context of integrated higher-level responses, e.g., sustainable land management are in scope. Considerations of costs, benefits, incentives and barriers, and the relationship to the SDGs may also be addressed.

The eighth bullet identifies that it may be appropriate to highlight case studies. For example to illustrate the efficacy of response options or to demonstrate instances where climate change is affecting land degradation (and vice versa).

Chapter 5: Food Security (~50 pages)

Input from John Porter and Cynthia Rosenzweig

- Framing and Context: food and nutrition security (availability, access, utilization, stability), food system, farming systems including agroforestry, food-energy-water nexus, and the role of desertification and land degradation
- Status, current trends and future projections of food and nutrition security linked to climate change, globally and regionally
- Attribution: distinguishing between climatic- and human-induced changes
- Impacts of climate change on food and nutrition security, including food production, prices and livelihoods
- Impacts of food and nutrition security on climate change
- Responses in terms of adaptation considering the full range of options, and their use
- GHG mitigation responses and their influence on food and nutritional security
- Synergies and trade-offs between adaptation and mitigation (considering scales, linkages, and co-benefits), sustainable land management

- Consequences of measures to enhance food and nutrition security for adaptation and mitigation in a changing climate
- Hotspots and case-studies

Food and nutrition security is a large and complex topic, and the chapter is expected to maintain a strong focus on links to climate change. The chapter will consider livestock and crop systems, as well as forestry. Aquaculture and freshwater fisheries may be relevant in the context of the potential for land and water management options to result in environmental impacts. It is recommended that the authors should signpost the relationship of this chapter with other relevant reports as appropriate to ensure to avoid duplication of effort and ensure complementarity.

The first, second and third bullets emphasise how climate change is intercalated with the four dimensions of food security: availability, access, utilization, and stability.

The fourth bullet considers the direct and indirect impacts of climate change on food and nutrition security. Examples of impacts that may be relevant include extreme events (e.g., flooding, drought), yield and nutrient composition responses to different temperature, precipitation, and CO_2 regimes, and changing pests and diseases. Indirect impacts might include price shocks and restricted access to food in urban areas due to disruption of food production and supply chains.

The fifth bullet focusses on feedback mechanisms whereby options to maintain and enhance food security may impact on climate change. Net GHG emissions from agricultural practices, land use, non-GHG forcings, food system value chain including energy use and food demand, loss and waste may be relevant here.

The sixth bullet explores adaptation options and their use. Examples might include, farm and water management, community-based adaptation, safety networks, ecosystem-based adaptation, climate risk management, demand-side management, as well as the capacity development required to achieve them.

The seventh bullet focusses on the impact of mitigation options on food and nutritional security such as the impact of measures to reduce GHG emissions (including methane and N_2O emissions), carbon sequestration and land-based mitigation (including competition for land), new technologies and demand-side measures (e.g., diet, food loss and waste), cost incentives and barriers.

The eighth bullet expands on the concept of sustainable land management in the context of climate change and food security. Sustainable land management means different things in different contexts. One way to address this may be to identify examples of synergies, trade-offs, side-effects or co-benefits associated with response options designed to maintain and enhance food and nutrition security in the context of climate change adaptation and mitigation.

The ninth bullet addresses actions to improve efficient production of higher-nutritional value food that may increase land availability for mitigation and adaptation.

Similarly to the two preceding chapters the tenth bullet identifies that it may be appropriate to highlight case studies.

Chapter 6: Interlinkages and integrative response options (~40 pages)

Input from Karen Seto and Cecile de Klein

- Combined and interactive effects between desertification, land degradation, food security and GHG fluxes, and scenarios
- Synergies/trade-offs/side-effects/co-benefits between response options including sustainable land management
- Impacts of land-based mitigation options on land degradation, desertification, food security, and ecosystems and their services
- Impacts of land-based adaptation options on land degradation, desertification, food security, and ecosystems and their services
- Land-based negative emissions
- Adaptation-mitigation interactions and co-benefits
- Competition for land

The focus of Chapter six should be upon the cross cutting relationships arising from the issues discussed in the previous chapters, while taking care to avoid unnecessary duplication. It will also be important to maintain a focus on issues that relate to climate change and ensure the chapter is complementary to chapter 7.

The first bullet focusses on linkages and interdependencies, for instance the UNCCD defines desertification as one extreme on the spectrum of land degradation. Land degradation can lead to reduction in ecosystem productivity, with associated risk to food security. Similarly loss of soil carbon due to land degradation can lead to increased GHG emissions. It may be appropriate here to provide a quantitative assessment of the combined effects of desertification and land degradation on food security and GHG emissions.

The second bullet extends the discussion on the effects of response options identified in previous chapters (i.e. response options to address desertification, land degradation, food security and terrestrial GHG emissions) with respect to the potential knock-on impacts. The concept of sustainable land management in the context of multiple drivers and pressures is relevant here. It may be helpful to provide examples of synergies, trade-offs, side-effects or co-benefits associated with the implementation of response options. Case studies of observed examples may also be useful.

The third bullet focusses on the potential cross cutting impacts of land-based mitigation options on land degradation, desertification, food security, and ecosystems and their services which go beyond those discussed in the earlier chapters. For example, effects of GHG emissions reduction; increased carbon sequestration to soils; biomass and other carbon pools; surface/albedo modification. Mitigation options may be implemented on many land types and impacts on ecosystem services provided by land including biodiversity and water may also be considered.

The fourth bullet focusses on the potential cross cutting impacts of land-based adaptation options on land degradation, desertification, food security, and ecosystems and their services which go beyond those discussed in the earlier chapters. For example, the impact of river management to prevent flooding of urban areas may have downstream impact on agricultural land. It could be appropriate to consider the possible impact on the range of ecosystem services provided including biodiversity, water etc.

The fifth bullet recognises the importance of negative emission options in many mitigation scenarios and the relevance to policy of an integrative cross cutting assessment. Negative emissions options may affect many land types. Possible impacts on the range of ecosystem services provided (including biodiversity, water etc.) may be considered. Of particular relevance to this discussion will be the findings of the Special Report Global Warming of 1.5^{o}C with respect to emissions and removals pathways.

The sixth bullet considers interactions between mitigation and adaptation options and potential co-benefits and trade-offs.

The seventh bullet builds on the overview of competition for land that will be presented in Chapter 1 envisaging that a more detailed assessment of the current and projected demands for land and the ecosystems services may be required. The role of sustainable land management could be further explored in this context. In addition, consideration could be given to the scale at which policy intervention can be effective to manage multiple and often competing demands for land and land based resources.

Chapter 7: Emergent risks, decision making, and sustainable development (~40 pages)

Input from John Morton and Margot Hurlbert

- Emergent risks from interaction of climate change with desertification, land degradation, and food security
- Management responses to areas of substantive risk arising from climate change
- Synergies and trade-offs of response options that affect sustainable development and climate change adaptation and mitigation
- Governance, institutions and decision-making across multiple scales that advance adaptation and mitigation, in the context of desertification, land degradation, food security and sustainable land management

The first bullet focusses on the processes of conceptualising and identifying emergent and substantive risks within the context of the definition of emergent risk provided in the IPCC AR5 WG2 glossary. Important characteristics of emergent risks that might be considered include non-linear transitions as environmental processes exceed system tipping points, compounding risks from more than one environmental process, and the cascading of environmental risks into complex social processes. Such risks may arise from the interaction of climate change and processes arising in at least one (but perhaps more) of the domains of desertification, land degradation, and food insecurity. Other substantive areas of emergent risk that it may be relevant to discuss include the overwhelming of humanitarian systems, migration, and conflict resulting from degradation of natural resources. Specific examples, for instance multi-bread basket failure, might be covered in this chapter or Chapter 5, as although this risk relates specifically to food insecurity, the risk cascades from and compounds with risks linked to degradation, desertification, shared management and governance responses.

The second bullet focusses on management responses to the identified areas of substantive risk and emergent risk, with the scale of the risks making it likely that most responses will be at the level of regional, national or international policy, and policy instruments supporting management responses.

The third bullet further develops the theme of synergies and trade-offs between the responses identified in Chapters 3, 4 and 5 to the combined impacts of climate change, desertification, land degradation and food insecurity, and other policies, instruments, and processes that promote sustainable development should be discussed. A discussion of such synergies and responses with reference to the 17 SDGs may be useful here, but other, longer-term framings of sustainable development and promoting sustainable livelihoods could also be useful.

The fourth bullet focusses on the role of governance and formal and informal institutions in decision-making processes that promote sustainable development. There are multiple scales at which governance structures and decision-making processes may be assessed. Examples identified during the group discussion included global through to national, sub-national, community and individual, geographical scales and from the earth system though river basins, to field scale, and timescales from the immediate to the multi-decadal. There may also be governance and institutional pre-conditions for public or community participation in addressing environmental risks, for example as mentioned in Article 6 of the UNFCCC, the SDGs and the UNCCD.

9. NEXT STEPS AND TIMELINE