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Online at www.gcci.earth/global/gem

GEM-GLO Content and References

GEM-GHG Emissions Monitoring – Domain Gobal

Version GCCIv1.2 Information Sheet on the GEM-GLO Variables Tabular List of Variables & SubVariables together with explanations and data source references

How-to-Read Template: **Format and content of the information per Variable in the Table below**

<table>
<tr><td colspan="3"></td></tr>
<tr><td rowspan="9">VN.
Variable N
Name
[Unit]</td><td colspan="2">Explanation: brief explanation of what Variable N expresses and optionally (e.g., in case of an index variable in units [%]) how it is computed</td></tr>
<tr><td colspan="2"><DataSourceShortCite V<i>N</i> string> (as cited within the chart at the GCCI data portal)</td></tr>
<tr><td rowspan="2">SV<i>N</i>.1
SubVariable <i>N</i>.1
Name</td><td><DateSources SV<i>N</i>.1 string> (from GCCIv1 SV definitions file)</td></tr>
<tr><td>Reference(s) to the data source(s) for SVN.1, incl DOIs, Weblinks, etc, as available (one or more detailed references)</td></tr>
<tr><td rowspan="2">SV<i>N</i>.2
SubVariable <i>N</i>.2
Name</td><td><DateSources SV<i>N</i>.2 string> (from GCCIv1 SV definitions file)</td></tr>
<tr><td>Reference(s) to the data source(s) for SVN.2, incl DOIs, Weblinks, etc, as available (one or more detailed references)</td></tr>
<tr><td rowspan="2">SV<i>N</i>.3
SubVariable <i>N</i>.3
Name</td><td><DateSources SV<i>N</i>.3 string> (from GCCIv1 SV definitions file)</td></tr>
<tr><td>Reference(s) to the data source(s) for SVN.3, incl DOIs, Weblinks, etc, as available (one or more detailed references)</td></tr>
<tr><td rowspan="2">SV<i>N</i>.4
SubVariable <i>N</i>.4
Name</td><td><DateSources SV<i>N</i>.4 string> (from GCCIv1 SV definitions file)</td></tr>
<tr><td>Reference(s) to the data source(s) for SVN.4, incl DOIs, Weblinks, etc, as available (one or more detailed references)</td></tr>
</table>

GEM-GLO Information Sheet Table: GEM-GHG Emissions Monitoring – Domain Global

Variable (V) Name	SubVariable (SV) Name	Variable Explanation and Data Source References
V1. CO2-based climate change (CC) mitigation index [%]		***Explanation:*** This is one of the two primary index variables of GEM-GLO, the one based on annual CO_2 emissions of countries, relevant country groups, and globally since 1990. It indicates the success of emission reductions in any given year as a percentage against the annual-average 1990-1994 CO_2 emissions ("Em(Year *i*)" vs "AvgEm(1990-1994)"). The SubVariables include the main GCCI climate change mitigation index (SVs 1.1&1.2) as well as the production-based (SVs 1.3&1.5) and consumption-based (SVs 1.4&1.6) emission reduction indices, respectively, either up to the latest year with data (first SVs) or also including a reduction scenario to 2050 compliant with the Paris climate goals ("incl path2Paris" SVs). The scenarios are modeled for GCCIv1 according to a simple "linear reduction & residual floor emission path model" of Kirchengast (2021) following Williges et al. (2021) (except for SVs 1.2&1.5 for Austria as explained in GEM-AT). This model provides 2017-2050 paths consistent with the CO_2 budget allocated to a country or country group on an equal-per-person basis from a remaining 2017-2050 global CO_2 budget of 700 $GtCO_2$ with a residual-floor annual global emission of 3.5 $GtCO_2$/yr. ***Formula for the GCCI climate change mitigation index gauging emission reductions:*** *(based on the production-based emission data)* **Index(Year *i*) [%] = 100 x [Em(Year *i*) / AvgEm(1990-1994) – 1]** *Formula for the production- and consumption-based emission reduction indices:* Index(Year *i*) [%] = 100 x [Em(Year *i*) / AvgEm(1990-1994)] The main GCCI index hence expresses the level of reductions against 0 % near 1990. It indicates success for achieving percentage values below 0 % towards –100 % (climate neutrality) while it indicates failure by values that stick above 0 % or even increase. The complementary two indices rather gauge the changes against 100 % near 1990.
		WEGC-GCCI 2021 & EEA-Eurst-GCP-EmDBs 2020
	SV1.1 GCCI CC mitigation index|CO2 emission reduction (goal -100% vs 1990-94=0%)	WEGC-GCCI/Kirc-etal 2021 – Kirchengast and Kohlfürst (2021). *Graz Climate Change Indicators (GCCI) Content and References Information Sheets—InfoSheet GEM-GLO.* DocID GCCIv1.2-GEM-GLO-Apr2022, Wegener Center, Univ. of Graz, Austria. Online at www.gcci.earth/global/gem (see under "Explanation" above on the index computation)
	SV1.2 GCCI CC mitigation index|CO2 emission reduction incl path2Paris	WEGC-GCCI/Kirc-etal 2021 (incl GCCIv1 EPClin&floor-scen) – Kirchengast and Kohlfürst (2021). Graz Climate Change Indicators (GCCI) Content and References Information Sheets—InfoSheet GEM-GLO. DocID GCCIv1.2-GEM-GLO-Apr2022, Wegener Center, Univ. of Graz, Austria. Online at www.gcci.earth/global/gem – Kirchengast (2021). *Simple budget-based linear&floor emission reduction path modeling* following Williges et al. (2021) *Fairness critically conditions the carbon budget allocation across countries.* Global Environ. Change in rev. (until online, available on request)
	SV1.3 Production-based CO2 emission	WEGC-GCCI/Kirc-etal 2021 & GCP-GloCarbProj 2020 – Kirchengast and Kohlfürst (2021). *Graz Climate Change Indicators (GCCI) Content and References Information Sheets—InfoSheet GEM-GLO.* DocID GCCIv1.2-GEM-GLO-Apr2022, Wegener Center,

	reduction index	Univ. of Graz, Austria. Online at www.gcci.earth/global/gem (see under "Explanation" above on the index computation) – Friedlingstein et al. (2020). Global Carbon Budget 2020. Earth Syst. Sci. Data, 12, 3269–3340, 2020. Online at https://doi.org/10.5194/essd-12-3269-2020
	SV1.4 Consumption-based CO2 emission reduction index	WEGC-GCCI/Kirc-etal 2021 & GCP-GloCarbProj 2020 – Kirchengast and Kohlfürst (2021). *Graz Climate Change Indicators (GCCI) Content and References Information Sheets—InfoSheet GEM-GLO.* DocID GCCIv1.2-GEM-GLO-Apr2022, Wegener Center, Univ. of Graz, Austria. Online at www.gcci.earth/global/gem (see under "Explanation" above on the index computation) – Friedlingstein et al. (2020). Global Carbon Budget 2020. Earth Syst. Sci. Data, 12, 3269–3340, 2020. Online at https://doi.org/10.5194/essd-12-3269-2020
	SV1.5 Production-based CO2 emission reduction index incl path2Paris	WEGC-GCCI/Kirc-etal 2021 (incl GCCIv1 EPClin&floor-scen) – Kirchengast and Kohlfürst (2021). *Graz Climate Change Indicators (GCCI) Content and References Information Sheets—InfoSheet GEM-GLO.* DocID GCCIv1.2-GEM-GLO-Apr2022, Wegener Center, Univ. of Graz, Austria. Online at www.gcci.earth/global/gem – Kirchengast (2021). *Simple budget-based linear&floor emission reduction path modeling* following Williges et al. (2021) *Fairness critically conditions the carbon budget allocation across countries.* Global Environ. Change in rev. (until online, available on request)
	SV1.6 Consumption-based CO2 emission reduction index incl path2Paris	WEGC-GCCI/Kirc-etal 2021 (incl GCCIv1 EPClin&floor-scen) – Kirchengast and Kohlfürst (2021). *Graz Climate Change Indicators (GCCI) Content and References Information Sheets—InfoSheet GEM-GLO.* DocID GCCIv1.2-GEM-GLO-Apr2022, Wegener Center, Univ. of Graz, Austria. Online at www.gcci.earth/global/gem – Kirchengast (2021). *Simple budget-based linear&floor emission reduction path modeling* following Williges et al. (2021) *Fairness critically conditions the carbon budget allocation across countries.* Global Environ. Change in rev. (until online, available on request)
V2. GHG-based climate change (CC) mitigation index [%]	***Explanation:*** See the explanation at the beginning of the Variable V1 block above—the SubVariables of this Variable V2 are constructed in exactly the same way but based on the annual greenhouse gas (GHG) emissions of countries, relevant country groups, and globally since 1990 rather than on CO_2 emissions only. The GHG emissions include all climate-relevant GHGs according to international accounting principles (also CH_4, N_2O, etc.) and are measured in Million tons of CO_2 equivalent [$MtCO_2eq$] (see under Variable V4 below). The scenarios to 2050 are in this case based on a remaining 2017-2050 global GHG budget of 1000 $GtCO_2eq$ with a residual-floor annual global emission of 5 $GtCO_2eq/yr$.	
	WEGC-GCCI 2021 & UN&GCP EmDBs 2020	
	SV2.1 GCCI CC mitigation index|GHG emission	WEGC-GCCI/Kirc-etal 2021 – Kirchengast and Kohlfürst (2021). *Graz Climate Change Indicators (GCCI) Content and References Information Sheets—InfoSheet GEM-GLO.* DocID GCCIv1.2-GEM-GLO-Apr2022, Wegener Center,

	reduction (goal -100% vs 1990-94=0%)	Univ. of Graz, Austria. Online at www.gcci.earth/global/gem (see under "Explanation" above on the index computation)
	SV2.2 GCCI CC mitigation index|GHG emission reduction incl path2Paris	WEGC-GCCI/Kirc-etal 2021 (incl GCCIv1 EPClin&floor-scen) – Kirchengast and Kohlfürst (2021). *Graz Climate Change Indicators (GCCI) Content and References Information Sheets—InfoSheet GEM-GLO.* DocID GCCIv1.2-GEM-GLO-Apr2022, Wegener Center, Univ. of Graz, Austria. Online at www.gcci.earth/global/gem – Kirchengast (2021). *Simple budget-based linear&floor emission reduction path modeling* following Williges et al. (2021) *Fairness critically conditions the carbon budget allocation across countries.* Global Environ. Change in rev. (until online, available on request)
	SV2.3 Production-based GHG emission reduction index	WEGC-GCCI/Kirc-etal 2021 & UN-EmissionsDB 2020 – Kirchengast and Kohlfürst (2021). *Graz Climate Change Indicators (GCCI) Content and References Information Sheets—InfoSheet GEM-GLO.* DocID GCCIv1.2-GEM-GLO-Apr2022, Wegener Center, Univ. of Graz, Austria. Online at www.gcci.earth/global/gem (see under "Explanation" above on the index computation) – United Nations Framework Convention on Climate Change (UNFCCC) (2020). *Greenhouse Gas Inventory Data*. Online at https://di.unfccc.int/time_series
	SV2.4 Consumption-based GHG emission reduction index	WEGC-GCCI/Kirc-etal 2021 & UN&GCP EmissionsDBs 2020 – Kirchengast and Kohlfürst (2021). *Graz Climate Change Indicators (GCCI) Content and References Information Sheets—InfoSheet GEM-GLO.* DocID GCCIv1.2-GEM-GLO-Apr2022, Wegener Center, Univ. of Graz, Austria. Online at www.gcci.earth/global/gem (see under "Explanation" above on the index computation) – United Nations Framework Convention on Climate Change (UNFCCC) (2020). *Greenhouse Gas Inventory Data*. Online at https://di.unfccc.int/time_series – Friedlingstein et al. (2020). Global Carbon Budget 2020. Earth Syst. Sci. Data, 12, 3269–3340, 2020. Online at https://doi.org/10.5194/essd-12-3269-2020
	SV2.5 Production-based GHG emissions incl path2Paris	WEGC-GCCI/Kirc-etal 2021 (incl GCCIv1 EPClin&floor-scen) – Kirchengast and Kohlfürst (2021). *Graz Climate Change Indicators (GCCI) Content and References Information Sheets—InfoSheet GEM-GLO.* DocID GCCIv1.2-GEM-GLO-Apr2022, Wegener Center, Univ. of Graz, Austria. Online at www.gcci.earth/global/gem – Kirchengast (2021). *Simple budget-based linear&floor emission reduction path modeling* following Williges et al. (2021) *Fairness critically conditions the carbon budget allocation across countries.* Global Environ. Change in rev. (until online, available on request)
	SV2.6 Consumption-based GHG emissions	WEGC-GCCI/Kirc-etal 2021 (incl GCCIv1 EPClin&floor-scen) – Kirchengast and Kohlfürst (2021). *Graz Climate Change Indicators (GCCI) Content and References Information Sheets—InfoSheet*

	incl path2Paris	*GEM-GLO.* DocID GCCIv1.2-GEM-GLO-Apr2022, Wegener Center, Univ. of Graz, Austria. Online at www.gcci.earth/global/gem – Kirchengast (2021). *Simple budget-based linear&floor emission reduction path modeling* following Williges et al. (2021) *Fairness critically conditions the carbon budget allocation across countries.* Global Environ. Change in rev. (until online, available on request)
V3. CO2 annual emissions [$MtCO_2$]	***Explanation:*** This is one of the two primary amount-of-emissions variables of GEM-GLO, the one based on annual CO_2 emissions of countries, relevant country groups, and globally since 1990 (except production-based CO_2 emissions being available from 1960). The SubVariables include production-based (SVs 3.1&3.3) and consumption-based (SVs 3.2&3.4) annual emissions measured in Million tons of CO_2 [$MtCO_2$], either up to the latest year with data (first SVs) or also including a reduction scenario to 2050 compliant with the Paris climate goals ("incl path2Paris" SVs). The scenarios are modeled for GCCIv1 according to a simple "linear reduction & residual floor emission path model" of Kirchengast (2021) following Williges et al. (2021) (except for SV3.3 for Austria as explained in GEM-AT). This model provides 2017-2050 paths consistent with the CO_2 budget allocated to a country or country group on an equal-per-person basis from a remaining 2017-2050 global CO_2 budget of 700 $GtCO_2$ with a residual-floor annual global emission of 3.5 $GtCO_2$/yr.	
	GCP-Global Carbon Project 2020 & WEGC 2021	
	SV3.1 Production-based CO2 emissions	GCP-Global Carbon Project 2020 / WEGCupd 2021 – Friedlingstein et al. (2020). *Global Carbon Budget 2020*. Earth Syst. Sci. Data, 12, 3269–3340, 2020. Online at https://doi.org/10.5194/essd-12-3269-2020
	SV3.2 Consumption-based CO2 emissions	GCP-Global Carbon Project 2020 / WEGCupd 2021 – Friedlingstein et al. (2020). *Global Carbon Budget 2020*. Earth Syst. Sci. Data, 12, 3269–3340, 2020. Online at https://doi.org/10.5194/essd-12-3269-2020
	SV3.3 Production-based CO2 emissions incl path2Paris	WEGC/Kirc-etal 2021 (incl GCCIv1 EPClin&floor-scen) – Kirchengast and Kohlfürst (2021). *Graz Climate Change Indicators (GCCI) Content and References Information Sheets—InfoSheet GEM-GLO.* DocID GCCIv1.2-GEM-GLO-Apr2022, Wegener Center, Univ. of Graz, Austria. Online at www.gcci.earth/global/gem (see also the reference under SubVariable SV3.1 above) – Kirchengast (2021). *Simple budget-based linear&floor emission reduction path modeling* following Williges et al. (2021) *Fairness critically conditions the carbon budget allocation across countries.* Global Environ. Change in rev. (until online, available on request)
	SV3.4 Consumption-based CO2 emissions incl path2Paris	WEGC/Kirc-etal 2021 (incl GCCIv1 EPClin&floor-scen) – Kirchengast and Kohlfürst (2021). *Graz Climate Change Indicators (GCCI) Content and References Information Sheets—InfoSheet GEM-GLO.* DocID GCCIv1.2-GEM-GLO-Apr2022, Wegener Center, Univ. of Graz, Austria. Online at www.gcci.earth/global/gem (see also the reference under SubVariable SV3.2 above) – Kirchengast (2021). *Simple budget-based linear&floor emission reduction path modeling* following Williges et al. (2021) *Fairness*

		critically conditions the carbon budget allocation across countries. Global Environ. Change in rev. (until online, available on request)
V4. GHG annual emissions [$MtCO_2eq$]	***Explanation:*** See the explanation at the beginning of the Variable V3 block above—the SubVariables of this Variable V4 are constructed in exactly the same way but based on the annual greenhouse gas (GHG) emissions of countries, relevant country groups, and globally since 1990 rather than on CO_2 emissions only. The GHG emissions include all climate-relevant GHGs according to international accounting principles (also CH_4, N_2O, etc.) and are measured in Million tons of CO_2 equivalent [$MtCO_2eq$]. The scenarios to 2050 are in this case based on a remaining 2017-2050 global GHG budget of 1000 $GtCO_2eq$ with a residual-floor annual global emission of 5 $GtCO_2eq/yr$. Compared to Variable V3, one additional amount-of-emissions SubVariable is available here for GHGs for most countries: the production-based GHG emissions including from land use change, which means to also count in the annual net emissions from Land Use, Land Use Change, and Forestry (LULUCF). These are sometimes negative in case the LULUCF sector acts as net sink (SV4.2 emissions are then lower than those of SV4.1).	
	UNFCCC & GCP EmissionsDBs & WEGC 2021	
	SV4.1 Production-based GHG emissions	UNFCCC EmissionsDB 2020 / WEGCupd 2021 – United Nations Framework Convention on Climate Change (UNFCCC) (2020). *Greenhouse Gas Inventory Data*. Online at https://di.unfccc.int/time_series
	SV4.2 Production-based GHG emissions incl from Land use change	UNFCCC EmissionsDB 2020 / WEGCupd 2021 – United Nations Framework Convention on Climate Change (UNFCCC) (2020). *Greenhouse Gas Inventory Data*. Online at https://di.unfccc.int/time_series
	SV4.3 Consumption-based GHG emissions	UNFCCC & GCP EmissionDBs 2020 / WEGCupd 2021 – United Nations Framework Convention on Climate Change (UNFCCC) (2020). *Greenhouse Gas Inventory Data*. Online at https://di.unfccc.int/time_series – Friedlingstein et al. (2020). *Global Carbon Budget 2020*. Earth Syst. Sci. Data, 12, 3269–3340, 2020. Online at https://doi.org/10.5194/essd-12-3269-2020
	SV4.4 Production-based GHG emissions incl path2Paris	WEGC/Kirc-etal 2021 (incl GCCIv1 EPClin&floor-scen) – Kirchengast and Kohlfürst (2021). *Graz Climate Change Indicators (GCCI) Content and References Information Sheets—InfoSheet GEM-GLO.* DocID GCCIv1.2-GEM-GLO-Apr2022, Wegener Center, Univ. of Graz, Austria. Online at www.gcci.earth/global/gem (see also the reference under SubVariable SV4.1 above) – Kirchengast (2021). *Simple budget-based linear&floor emission reduction path modeling* following Williges et al. (2021) *Fairness critically conditions the carbon budget allocation across countries.* Global Environ. Change in rev. (until online, available on request)
	SV4.5 Consumption-based GHG	WEGC/Kirc-etal 2021 (incl GCCIv1 EPClin&floor-scen) – Kirchengast and Kohlfürst (2021). *Graz Climate Change Indicators (GCCI) Content and References Information Sheets—InfoSheet*

	emissions incl path2Paris	*GEM-GLO.* DocID GCCIv1.2-GEM-GLO-Apr2022, Wegener Center, Univ. of Graz, Austria. Online at www.gcci.earth/global/gem (see also the references under SubVariable SV4.3 above) – Kirchengast (2021). *Simple budget-based linear&floor emission reduction path modeling* following Williges et al. (2021) *Fairness critically conditions the carbon budget allocation across countries.* Global Environ. Change in rev. (until online, available on request)
V5. CO2 annual emissions per person [tCO_2/Person]	***Explanation:*** This is one of the two primary amount-of-emissions-per-person variables of GEM-GLO, the one based on annual CO_2 emissions of countries, relevant country groups, and globally since 1990 (except production-based CO_2 emissions per person available from 1960). The per-person data of this variable are derived from dividing the amount-of-emissions data of Variable V3 by the respective population size data (Variable V7 below). The SubVariables include production-based (SVs 5.1&5.3) and consumption-based (SVs 5.2&5.4) annual emissions per person measured in tons of CO_2 per person [tCO_2/Person], either up to the latest year with data (first SVs) or also including a reduction scenario to 2050 compliant with the Paris climate goals ("incl path2Paris" SVs). The relevant amount-of-emission scenarios are modeled for GCCIv1 according to a simple "linear reduction & residual floor emission path model" of Kirchengast (2021) following Williges et al. (2021) (except for SV5.3 for Austria as explained in GEM-AT). This model provides 2017-2050 paths consistent with the CO_2 budget allocated to a country or country group on an equal-per-person basis from a remaining 2017-2050 global CO_2 budget of 700 $GtCO_2$ with a residual-floor annual global emission of 3.5 $GtCO_2$/yr (i.e., same data as for Variable V3, just divided by the respective scenario-based population size data of Variable V7).	
	GCP-EmissionDB & UN-PopDB 2020 & WEGC 2021	
	SV5.1 Production-based CO2 emissions per Person	GCP-EmDB & UN-PopDB 2020 / WEGCupd 2021 – Friedlingstein et al. (2020). *Global Carbon Budget 2020*. Earth Syst. Sci. Data, 12, 3269–3340, 2020. Online at https://doi.org/10.5194/essd-12-3269-2020 – United Nations (UN) (2020). *Population Dynamics*. Department of Economic and Social Affairs. Online at https://population.un.org/wpp/Download/Standard/Population/
	SV5.2 Consumption-based CO2 emissions per Person	GCP-EmDB & UN-PopDB 2020 / WEGCupd 2021 – Friedlingstein et al. (2020). *Global Carbon Budget 2020*. Earth Syst. Sci. Data, 12, 3269–3340, 2020. Online at https://doi.org/10.5194/essd-12-3269-2020 – United Nations (UN) (2020). *Population Dynamics*. Department of Economic and Social Affairs. Online at https://population.un.org/wpp/Download/Standard/Population/
	SV5.3 Production-based CO2 emissions per Person incl path2Paris	WEGC/Kirc-etal 2021 (incl GCCIv1 EPClin&floor-scen) Kirchengast and Kohlfürst (2021). *Graz Climate Change Indicators (GCCI) Content and References Information Sheets—InfoSheet GEM-GLO.* DocID GCCIv1.2-GEM-GLO-Apr2022, Wegener Center, Univ. of Graz, Austria. Online at www.gcci.earth/global/gem (see also the references under SubVariable SV5.1 above)

		– Kirchengast (2021). *Simple budget-based linear&floor emission reduction path modeling* following Williges et al. (2021) *Fairness critically conditions the carbon budget allocation across countries.* Global Environ. Change in rev. (until online, available on request)
	SV5.4 Consumption-based CO2 emissions per Person incl path2Paris	WEGC/Kirc-etal 2021 (incl GCCIv1 EPClin&floor-scen) – Kirchengast and Kohlfürst (2021). *Graz Climate Change Indicators (GCCI) Content and References Information Sheets—InfoSheet GEM-GLO.* DocID GCCIv1.2-GEM-GLO-Apr2022, Wegener Center, Univ. of Graz, Austria. Online at www.gcci.earth/global/gem (see also the references under SubVariable SV5.2 above) – Kirchengast (2021). *Simple budget-based linear&floor emission reduction path modeling* following Williges et al. (2021) *Fairness critically conditions the carbon budget allocation across countries.* Global Environ. Change in rev. (until online, available on request)
V6. GHG annual emissions per person [tCO_2eq/Person]	***Explanation:*** See the explanation at the beginning of the Variable V5 block above—the SubVariables of this Variable V5 are constructed in exactly the same way but based on the annual greenhouse gas (GHG) emissions of countries, relevant country groups, and globally since 1990 rather than on CO_2 emissions only. The GHG emissions include all climate-relevant GHGs according to international accounting principles (also CH_4, N_2O, etc.) and are, on a per-person basis, measured in tons of CO_2 equivalent per person [tCO_2eq/Person]. The scenarios to 2050 are in this case based on a remaining 2017-2050 global GHG budget of 1000 $GtCO_2eq$ with a residual-floor annual global emission of 5 $GtCO_2eq$/yr. Compared to Variable V5, one additional amount-of-emissions-per-person SubVariable is available here for GHGs for most countries: the production-based GHG emissions per person including from land use change, which means to also count in the annual net emissions from Land Use, Land Use Change, and Forestry (LULUCF). These are negative in case the LULUCF sector acts as net sink (in which case the SV6.2 emissions are then lower than those of SV6.1).	
	UNFCCC&GCP-EmDBs & UN-PopDB 2020 & WEGC 2021	
	SV6.1 Production-based GHG emissions per Person	UNFCCC-EmDB & UN-PopDB 2020 / WEGCupd 2021 – United Nations Framework Convention on Climate Change (UNFCCC) (2020). *Greenhouse Gas Inventory Data*. Online at https://di.unfccc.int/time_series – United Nations (UN) (2020). *Population Dynamics*. Department of Economic and Social Affairs. Online at https://population.un.org/wpp/Download/Standard/Population/
	SV6.2 Production-based GHG emissions per Person incl from Land use change	UNFCCC-EmDB & UN-PopDB 2020 / WEGCupd 2021 – United Nations Framework Convention on Climate Change (UNFCCC) (2020). *Greenhouse Gas Inventory Data*. Online at https://di.unfccc.int/time_series – United Nations (UN) (2020). *Population Dynamics*. Department of Economic and Social Affairs. Online at https://population.un.org/wpp/Download/Standard/Population/
		UNFCCC&GCP-EmDBs & UN-PopDB 2020 / WEGCupd 2021

	SV6.3 Consumption-based GHG emissions per Person	– United Nations Framework Convention on Climate Change (UNFCCC) (2020). *Greenhouse Gas Inventory Data*. Online at https://di.unfccc.int/time_series – Friedlingstein et al. (2020). *Global Carbon Budget 2020*. Earth Syst. Sci. Data, 12, 3269–3340, 2020. Online at https://doi.org/10.5194/essd-12-3269-2020 – United Nations (UN) (2020). *Population Dynamics*. Department of Economic and Social Affairs. Online at https://population.un.org/wpp/Download/Standard/Population/
	SV6.4 Production-based GHG emissions per Person incl path2Paris	WEGC/Kirc-etal 2021 (incl GCCIv1 EPClin&floor-scen) – Kirchengast and Kohlfürst (2021). *Graz Climate Change Indicators (GCCI) Content and References Information Sheets—InfoSheet GEM-GLO.* DocID GCCIv1.2-GEM-GLO-Apr2022, Wegener Center, Univ. of Graz, Austria. Online at www.gcci.earth/global/gem (see also the references under SubVariable SV6.1 above) – Kirchengast (2021). *Simple budget-based linear&floor emission reduction path modeling* following Williges et al. (2021) *Fairness critically conditions the carbon budget allocation across countries.* Global Environ. Change in rev. (until online, available on request)
	SV6.5 Consumption-based GHG emissions per Person incl path2Paris	WEGC/Kirc-etal 2021 (incl GCCIv1 EPClin&floor-scen) – Kirchengast and Kohlfürst (2021). *Graz Climate Change Indicators (GCCI) Content and References Information Sheets—InfoSheet GEM-GLO.* DocID GCCIv1.2-GEM-GLO-Apr2022, Wegener Center, Univ. of Graz, Austria. Online at www.gcci.earth/global/gem (see also the references under SubVariable SV6.3 above) – Kirchengast (2021). *Simple budget-based linear&floor emission reduction path modeling* following Williges et al. (2021) *Fairness critically conditions the carbon budget allocation across countries.* Global Environ. Change in rev. (until online, available on request)

V7. GHG annual concentrations [ppm]	***Explanation*:** This variable provides annual global greenhouse gas (GHG) concentrations in the atmosphere since 1960 in two forms: 1. CO_2-equivalent concentration (SV7.1), which is the concentration that CO_2 would have in the air if the total radiative forcing of all GHGs (incl. also CH_4, N_2O, etc.) would come from CO_2 only, and 2. the concentration of just CO_2, which is the main GHG that has contributed about 80 % of the radiative forcing increase since 1990 that drives global warming (see under CWM-GLO for a range of global warming-related variables, including radiative forcing). The units of parts per million [ppm], used for expressing concentrations of trace gases such as CO_2 in the air, denote the number of molecules of a trace gas per million of total air molecules. In Earth's atmosphere about 99 % of this total are made up by molecular nitrogen (N_2) and oxygen (O_2), termed the main constituents of the air.	
	NOAA 2020 & Meinetal 2017 & Etmietal 2016 & WEGC 2021	
	SV7.1 CO2-equivalent concentration (all GHGs)	NOAA 2020 & Meinsh-etal 2017 & Etmin-etal 2016 / WEGCupd 2021 – Meinshausen et al. (2017). *Historical greenhouse gas concentrations for climate modelling (CMIP6)*. Geosci. Model Dev., 10, 2057-2116. Online at https://doi.org/10.5194/gmd-10-2057-2017 – Butler and Montzka-NOAA (2020). *The NOAA Annual Greenhouse Gas Index (AGGI)*. Online at https://gml.noaa.gov/aggi/aggi.html

		– Etminan et al. (2016). *Radiative forcing of carbon dioxide, methane, and nitrous oxide: A significant revision of the methane radiative forcing*. Geophys. Res. Lett., 43, 12,614–12,623. Online at https://doi.org/10.1002/2016GL071930
	SV7.2 CO2 concentration (no other GHGs)	NOAA 2020 & Meinsh-etal 2017 / WEGCupd 2021
		– Meinshausen et al. (2017). *Historical greenhouse gas concentrations for climate modelling (CMIP6).* Geosci. Model Dev., 10, 2057-2116. Online at https://doi.org/10.5194/gmd-10-2057-2017 – Butler and Montzka-NOAA (2020). *The NOAA Annual Greenhouse Gas Index (AGGI)*. Online at https://gml.noaa.gov/aggi/aggi.html
V8. Population size [No. of Persons]	***Explanation:*** This auxiliary variable of GEM-GLO provides the population size of countries, relevant country groups, and globally since 1960. It expresses on an annual basis the number of residents, counted as [No. of Persons], who live in countries, relevant country groups, and globally. While the annual population sizes up to the latest year with data (SV7.1) are based on population census data collected by the UN, the scenario data to 2050 (SV7.2) are drawn from the UN population dynamics database, using the "medium estimate" scenario. In this scenario the global population rises from about 7.7 to 9.7 billion over 2019 to 2050 while, for example, the European one slightly decreases from about 615 to 590 million residents.	
	UN PopulationDB 2020 & WEGCupd 2021	
	SV8.1 Past-to-present population size	UN PopDB 2020 / WEGCupd 2021
		– United Nations (UN) (2020). *Population Dynamics*. Department of Economic and Social Affairs. Online at https://population.un.org/wpp/Download/Standard/Population/
	SV8.2 Scenario-based population size	UN PopDB 2020 / WEGCupd 2021
		– United Nations (UN) (2020). *Population Dynamics*. Department of Economic and Social Affairs. Online at https://population.un.org/wpp/Download/Standard/Population/
V9. Economic data [Billions of EUR]	***Explanation:*** This auxiliary variable provides economic indicators since 1999 in its two subvariables. Both of these are inflation-adjusted which is marked by the word real. SV9.1 describes the real gross domestic product (GDP) which is the value of all goods and services produced or exerted within a country's borders. For aggregated regions the country level data is summed up. SV9.2 shows real purchasing power parity (PPP), which is GDP in terms of an exchange rate between countries that accounts for the value of a fixed basket of goods rather than the market exchange rates. In this manner it is less volatile than the market exchange rate. Both quantities are given in Euros (EUR).	
	WEO/IMF Economic Data 2021	
	SV9.1 Gross Domestic	WEO/IMF Economic Data 2021
		– International Monetary Fund (IMF) (2021). *World Economic Outlook: Recovery during a Pandemic—Health Concerns, Supply Disruptions, Price Pressures.* International Monetary Fund, Publication Services. Online at

	Product (real GDP)	https://www.imf.org/en/Publications/WEO/weo-database/2021/October – International Monetary Fund (IMF) (2021). *Exchange rates incl. Effective exchange rates.* Online at https://data.imf.org
	SV9.2 Purchasing Power Parity (real PPP)	WEO/IMF Economic Data 2021 – International Monetary Fund (IMF) (2021). *World Economic Outlook: Recovery during a Pandemic—Health Concerns, Supply Disruptions, Price Pressures.* International Monetary Fund, Publication Services. Online at https://www.imf.org/en/Publications/WEO/weo-database/2021/October – International Monetary Fund (IMF) (2021). *Exchange rates incl. Effective exchange rates.* Online at https://data.imf.org
V10. Economic data per person [EUR per person]	***Explanation:*** This diagnostic variable shows economic data on a per capita basis. It uses the same data as described in Variable V9 divided by the population data in Variable V8. This makes data between countries easier to compare. The values are given in Euros per person (EUR per person). SV10.1 shows GDP per person and SV10.2 shows PPP per person.	
	WEO/IMF 2021 & UN-PopDB 2020/WEGCupd 2021	
	SV10.1 Gross Domestic Product (realGDP) per Person	WEO/IMF 2021 & UN-PopDB 2020/WEGCupd 2021 – International Monetary Fund (IMF) (2021). *World Economic Outlook: Recovery during a Pandemic—Health Concerns, Supply Disruptions, Price Pressures.* International Monetary Fund, Publication Services. Online at https://www.imf.org/en/Publications/WEO/weo-database/2021/October – International Monetary Fund (IMF) (2021). *Exchange rates incl. Effective exchange rates.* Online at https://data.imf.org – United Nations (UN) (2020). *Population Dynamics*. Department of Economic and Social Affairs. Online at https://population.un.org/wpp/Download/Standard/Population/
	SV10.2 Purchasing Power Parity (real PPP) per Person	WEO/IMF 2021 & UN-PopDB 2020/WEGCupd 2021 – International Monetary Fund (IMF) (2021). *World Economic Outlook: Recovery during a Pandemic—Health Concerns, Supply Disruptions, Price Pressures.* International Monetary Fund, Publication Services. Online at https://www.imf.org/en/Publications/WEO/weo-database/2021/October – International Monetary Fund (IMF) (2021). *Exchange rates incl. Effective exchange rates.* Online at https://data.imf.org – United Nations (UN) (2020). *Population Dynamics*. Department of Economic and Social Affairs. Online at https://population.un.org/wpp/Download/Standard/Population/
V11. CO_2 emissions per GDP and PPP	***Explanation:*** This variable is one of two variables in GCCI that compares emissions and economy. Here the CO_2 emission data from Variable V3 are divided by the GDP and PPP data to show how economy and emissions are related. CO_2 emissions per GDP and PPP are measured in tonnes of CO_2 per million Euro (tCO_2pMEUR). Details on the emission	

[Tonnes of CO2 per Million EUR]	calculations can be read in the description of V3. The four subvariables of include production- and consumption-based emissions per GDP and PPP, respectively.	
	GCP-EmissionDB & WEO/IMF EconData 2021 & WEGC2021	
	SV11.1 Production-based CO2 emissions per GDP	GCP-EmDB & WEO/IMF2021 & WEGC2021 – Friedlingstein et al. (2020). Global Carbon Budget 2020. Earth Syst. Sci. Data, 12, 3269–3340, 2020. Online at https://doi.org/10.5194/essd-12-3269-2020 – International Monetary Fund (IMF) (2021). *Exchange rates incl. Effective exchange rates.* Online at https://data.imf.org – International Monetary Fund (IMF) (2021). *World Economic Outlook: Recovery during a Pandemic—Health Concerns, Supply Disruptions, Price Pressures.* International Monetary Fund, Publication Services. Online at https://www.imf.org/en/Publications/WEO/weo-database/2021/October – United Nations (UN) (2020). *Population Dynamics*. Department of Economic and Social Affairs. Online at https://population.un.org/wpp/Download/Standard/Population/
	SV11.2 Consumption-based CO2 emissions per GDP	GCP-EmDB & WEO/IMF2021 & WEGC2021 – Friedlingstein et al. (2020). Global Carbon Budget 2020. Earth Syst. Sci. Data, 12, 3269–3340, 2020. Online at https://doi.org/10.5194/essd-12-3269-2020 – International Monetary Fund (IMF) (2021). *Exchange rates incl. Effective exchange rates.* Online at https://data.imf.org – International Monetary Fund (IMF) (2021). *World Economic Outlook: Recovery during a Pandemic—Health Concerns, Supply Disruptions, Price Pressures.* International Monetary Fund, Publication Services. Online at https://www.imf.org/en/Publications/WEO/weo-database/2021/October – United Nations (UN) (2020). *Population Dynamics*. Department of Economic and Social Affairs. Online at https://population.un.org/wpp/Download/Standard/Population/
	SV11.3 Production-based CO2 emissions per PPP	GCP-EmDB & WEO/IMF2021 & WEGC2021 – Friedlingstein et al. (2020). Global Carbon Budget 2020. Earth Syst. Sci. Data, 12, 3269–3340, 2020. Online at https://doi.org/10.5194/essd-12-3269-2020 – International Monetary Fund (IMF) (2021). *Exchange rates incl. Effective exchange rates.* Online at https://data.imf.org – International Monetary Fund (IMF) (2021). *World Economic Outlook: Recovery during a Pandemic—Health Concerns, Supply Disruptions, Price Pressures.* International Monetary Fund, Publication Services. Online at https://www.imf.org/en/Publications/WEO/weo-database/2021/October – United Nations (UN) (2020). *Population Dynamics*. Department of Economic and Social Affairs. Online at https://population.un.org/wpp/Download/Standard/Population/
		GCP-EmDB & WEO/IMF2021 & WEGC2021

	SV11.4 Consumption-based CO2 emissions per PPP	– Friedlingstein et al. (2020). Global Carbon Budget 2020. Earth Syst. Sci. Data, 12, 3269–3340, 2020. Online at https://doi.org/10.5194/essd-12-3269-2020 – International Monetary Fund (IMF) (2021). *Exchange rates incl. Effective exchange rates.* Online at https://data.imf.org – International Monetary Fund (IMF) (2021). *World Economic Outlook: Recovery during a Pandemic—Health Concerns, Supply Disruptions, Price Pressures.* International Monetary Fund, Publication Services. Online at https://www.imf.org/en/Publications/WEO/weo-database/2021/October – United Nations (UN) (2020). *Population Dynamics*. Department of Economic and Social Affairs. Online at https://population.un.org/wpp/Download/Standard/Population/
V12. GHG emissions per GDP and PPP [Tonnes of CO2 per Million EUR]	***Explanation:*** This is the second emission-per-economy variable and it is calculated in the same manner as Variable V11 but using GHG emissions from Variable V4. Details on the emission calculations can be read in the description of V4. The GHG emissions per GDP and PPP are given in tonnes of CO2 equivalents per million Euro (tCO2eqpMEUR). The four subvariables include production- and consumption-based emissions per GDP and PPP, respectively.	
	UNFCCC & GCP-EmDB & WEO/IMF EconData 2021 & WEGC2021	
	SV12.1 Production-based GHG emissions per GDP	UNFCCC-EmDB & WEO/IMF 2021 & WEGC2021 United Nations Framework Convention on Climate Change (UNFCCC) (2020). *Greenhouse Gas Inventory Data*. Online at https://di.unfccc.int/time_series International Monetary Fund (IMF) (2021). *Exchange rates incl. Effective exchange rates.* Online at https://data.imf.org International Monetary Fund (IMF) (2021). *World Economic Outlook: Recovery during a Pandemic—Health Concerns, Supply Disruptions, Price Pressures.* International Monetary Fund, Publication Services. Online at https://www.imf.org/en/Publications/WEO/weo-database/2021/October United Nations (UN) (2020). *Population Dynamics*. Department of Economic and Social Affairs. Online at https://population.un.org/wpp/Download/Standard/Population/
	SV12.2 Consumption-based GHG emissions per GDP	UNFCCC-EmDB & WEO/IMF 2021 & WEGC2021 United Nations Framework Convention on Climate Change (UNFCCC) (2020). *Greenhouse Gas Inventory Data*. Online at https://di.unfccc.int/time_series International Monetary Fund (IMF) (2021). *Exchange rates incl. Effective exchange rates.* Online at https://data.imf.org International Monetary Fund (IMF) (2021). *World Economic Outlook: Recovery during a Pandemic—Health Concerns, Supply Disruptions, Price Pressures.* International Monetary Fund, Publication Services. Online at https://www.imf.org/en/Publications/WEO/weo-database/2021/October United Nations (UN) (2020). *Population Dynamics*. Department of Economic and Social Affairs. Online at https://population.un.org/wpp/Download/Standard/Population/

	SV12.3 Production-based GHG emissions per PPP	UNFCCC-EmDB & WEO/IMF 2021 & WEGC2021 – United Nations Framework Convention on Climate Change (UNFCCC) (2020). *Greenhouse Gas Inventory Data*. Online at https://di.unfccc.int/time_series – International Monetary Fund (IMF) (2021). *Exchange rates incl. Effective exchange rates.* Online at https://data.imf.org – International Monetary Fund (IMF) (2021). *World Economic Outlook: Recovery during a Pandemic—Health Concerns, Supply Disruptions, Price Pressures.* International Monetary Fund, Publication Services. Online at https://www.imf.org/en/Publications/WEO/weo-database/2021/October – United Nations (UN) (2020). *Population Dynamics*. Department of Economic and Social Affairs. Online at https://population.un.org/wpp/Download/Standard/Population/
	SV12.4 Consumption-based GHG emissions per PPP	UNFCCC-EmDB & WEO/IMF 2021 & WEGC2021 – United Nations Framework Convention on Climate Change (UNFCCC) (2020). *Greenhouse Gas Inventory Data*. Online at https://di.unfccc.int/time_series – International Monetary Fund (IMF) (2021). *Exchange rates incl. Effective exchange rates.* Online at https://data.imf.org – International Monetary Fund (IMF) (2021). *World Economic Outlook: Recovery during a Pandemic—Health Concerns, Supply Disruptions, Price Pressures.* International Monetary Fund, Publication Services. Online at https://www.imf.org/en/Publications/WEO/weo-database/2021/October – United Nations (UN) (2020). *Population Dynamics*. Department of Economic and Social Affairs. Online at https://population.un.org/wpp/Download/Standard/Population/