

## APPENDIX B – SPATIAL CONSTRAINTS ANALYSIS



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## Spatial Constraints Analysis

### 1. Spatial constraints likely due to climate and air quality receptors

#### A) On-shore wind power developments

As shown in Figure CA1 and Table 7-2, there are a number of areas across Ukraine likely to present constraints to on-shore wind power developments. These spatial constraints arise due to the sensitivity of the Climate and Air Quality topic receptors to on-shore wind power development, as well as the technical exclusions which are common to all the on-shore wind development maps (described further in Section 4.2 and Section 7.4).

There are no areas considered to be of ‘high’ sensitivity to the on-shore wind renewable energy scenario under consideration. Therefore, outside of the technically excluded areas, there are no areas that are likely to present major constraints to the implementation of on-shore wind development with regards to Climate and Air Quality. However, urban areas and their immediate surrounds are identified as being of ‘medium’ sensitivity due to potential impacts upon air quality.

Urban areas are considered to be of greater sensitivity to air quality impacts due to the higher baseline air pollutant levels and air quality pressures that exist within urban areas; such pressures would be compounded by additional sources of air pollution arising from the on-shore wind power development renewable energy scenario. However, it is important to note that potential changes to air quality are also important in rural areas. Further analysis of potential constraints associated with air quality within both rural and urban areas would be required prior to the implementation of an on-shore wind project funded by USELF.

As can be seen from Figure CA1, spatial constraints are presented by the scattering of urban areas across Ukraine. Particularly notable areas include the towns and cities of southern Luhansk; and the dense scattering of towns across the western oblasts of L’viv, Volyn, Ivano-Frankivsk, Rivne, Ternopil and Vinnytsia.

The two Climate and Air Quality receptors which were not mapped (*Climate* and *Odour*) were both assessed as having a sensitivity of ‘none’ to the on-shore wind power development renewable energy scenario.

#### B) Small hydropower developments

As shown in Figure CA2 and Table 7-2, the sensitivity classifications for all the Climate and Air Quality receptors under the small hydropower development renewable energy scenario are identical to those for the on-shore wind development renewable energy scenario. Therefore, outside of the technically excluded areas, there are no areas that are likely to present major spatial constraints with regards to Climate and Air Quality. However, urban areas and their immediate surrounds have been identified as being of ‘medium’ sensitivity due to potential impacts upon air quality.

As with the on-shore wind renewable energy scenario, the areas identified as presenting spatial constraints for small hydropower development are spread widely across Ukraine. These areas are similar to those discussed above in Paragraph A; however, due to the different technical exclusions that apply to the small hydropower renewable energy scenario, there are some notable additional areas which have the potential for small-hydropower development but that do present spatial constraints. These include the major urban areas around Kyiv, Kharkiv, Dnipropetrovs'k, Kryvyi Rih, Odessa, Luhans'k, Syeverodonets'k, Donetsk, Makeyevka and Gorlovka; as well as the dense scattering of smaller urban areas across the western oblasts (see Figure CA2).

### C) Solar photovoltaic developments

As shown in Figure CA3 and Table 7-2, the sensitivity classifications for all the Climate and Air Quality receptors under the solar photovoltaic development renewable energy scenario are identical to those for the on-shore wind and small hydropower renewable energy scenarios.

Although the solar photovoltaic renewable energy scenario has different technical exclusions, the areas identified as presenting spatial constraints to small hydropower development are also generally applicable to solar photovoltaic development; and the text provided in Paragraph B is therefore applicable.

### D) Biomass developments

As shown in Figure CA4, Figure CA5 and Table 7-2, the sensitivity classifications for the *Air Quality* receptor under the biomass development renewable energy scenario are identical to those for the on-shore wind development renewable energy scenario. However, the sensitivity classifications for the two unmapped Climate and Air Quality receptors (*Climate* and *Odour*) are different. Both of these unmapped receptors are assessed as being of 'medium' sensitivity to the biomass development renewable energy scenario under consideration. Further detailed analysis would be required in order to ascertain any spatial constraints arising associated with these receptors prior to the implementation of a biomass project funded by USELF.

The biomass renewable energy scenario has different technical exclusions depending on whether the biomass fuel to be used is derived from agricultural residues or wood residues. These different technical exclusions are shown in Figures CA4 and CA5 and described further below.

#### i. *Biomass using agricultural residues*

Figure CA4 shows that the areas identified as presenting spatial constraints to small hydropower development are also applicable to biomass development using agricultural residues; and the text provided in Paragraph B is therefore applicable. However, there are a large number of additional small urban areas that are also relevant under the biomass renewable energy scenario using agricultural residues, as they are not technically excluded like they are under the small hydropower renewable energy scenario. As can be seen by comparing Figure CA2 and CA4, these additional areas include settlements throughout the western oblasts, including the Carpathian Mountains.

ii. *Biomass using wood residues*

As shown in Figure CA5 and described further in Section 4.2.5 and Section 7.4, only the following oblasts are suitable for supporting a 5 MW or greater biomass CHP system using wood residues: Chernihiv, Kyiv, Zhytomyr, Sumy, Chernivtsi, Vinnytsia, L'viv, Rivne and Zakarpattia (see also Figure 4-4 which shows the economic potential for wood biomass power generation for each oblast). As detailed in Section 4.2.5, a biomass CHP system should be within 100km of the source of the fuel supply; therefore, the spatial constraints identified for the biomass renewable energy scenario and mapped in Figure CA5 apply within the oblasts listed and also within a 100km buffer of these oblasts. This constraint technically excludes development from within the southern and eastern oblasts and Crimea.

E) Biogas developments

As shown in Figure CA6, Figure CA7 and Table 7-2, the sensitivity classifications for the *Air Quality* receptor under the biogas development renewable energy scenario are identical to those for the on-shore wind development renewable energy scenario. The sensitivity classification for the unmapped *Odour* receptor is 'medium'; and would require further detailed analysis to identify any spatial constraints associated with this receptor prior to the implementation of a biomass project funded by USELF. The sensitivity classification for the unmapped *Climate* receptor to the biogas development renewable energy scenario is assessed as being 'none'.

The biogas renewable energy scenario has different technical exclusions depending on whether the biogas is to be derived from animal manure or municipal landfill gas. These different technical exclusions are shown in Figures CA6 and CA7.

i. *Biogas using animal manure*

Figure CA6 shows that the areas identified as presenting spatial constraints to biomass using agricultural residues are also applicable to biogas development using animal manure; and the text provided in Paragraph Di is therefore applicable.

ii. *Biogas using municipal landfill gas*

As shown in Figure CA7 and described further in Section 4.2.6 and Section 7.4, only 25 sites have been investigated for power and heat conversion potential. Therefore, the spatial constraints for the biogas renewable energy scenario only apply to the locations of these 25 sites and their immediate surrounds (up to 10km). The 25 sites are associated with 19 cities which have high populations. These are, in order of population: Kyiv, Kharkiv, Dnipropetrovsk, Odessa, Donetsk, Zaporizhia, L'viv, Mariupol, Luhansk, Vinnytsia, Chernihiv, Sumy, Rivne, Khmelnytskyi, Chernivtsi, Ivano-Frankivsk, Luts'k, Yalta, and Alushta.

## **2. Surface water and groundwater**

A) On-shore wind power developments

As shown in Figure SW1 and Table 7-2, there are a number of areas within Ukraine likely to present constraints to on-shore wind power developments. These spatial constraints arise due to the sensitivity of the Surface water and Groundwater topic receptors to on-shore wind power

development, as well as the technical exclusions which are common to all the on-shore wind development maps (described further in Section 4.2 and Section 7.4).

There are no areas considered to be of ‘high’ sensitivity to the on-shore wind renewable energy scenario under consideration. Therefore, outside of the technically excluded areas, there are no areas that are likely to present major constraints to the implementation of on-shore wind development with regards to Surface Water and Groundwater. However, areas near to surface water are identified as being of ‘medium’ sensitivity due to potential impacts upon surface water quality, resources and flooding regimes (these potential impacts are described in Section 8.2.3).

All river channels and surface water bodies are potentially sensitive to on-shore wind power development. However, particular areas that are likely to present spatial constraints to this renewable energy scenario are those in close proximity to the major rivers and their tributaries; including, in particular, the Dnipro, the Dniester, the Severskiy Donets and the Azov Rivers.

Risk of adverse water quality, resources and flooding impacts resulting from an on-shore wind power development will vary according to river catchment; and not all areas identified as being of medium sensitivity will necessarily be shown to place significant constraints upon wind power development once project-level environmental studies are completed. Oblasts that are likely to contain areas that present fewer constraints in this regard include those with rivers which historically do not exceed a maximum level of flood water rise of two metres during flood; for example, Odessa, the southern areas of Kherson and northern Crimea (see Figure 3-8 of the SER Topic Paper).

Areas in which more than 25% of total water use is sourced from groundwater are considered to be of ‘medium’ sensitivity due to potential impacts upon groundwater quality and groundwater resource (see Section 8.2.3). This will be a potential constraint, requiring further detailed investigation, for any project seeking to develop on-shore wind within the oblasts of: Volyn, L’viv, Ternopil, Ivano-Frankivsk, Khmelnytskyi, Vinnytsia, Odessa, Mykolaiv, Kherson, Zaporizhia, Donetsk, Kharkiv, and Luhansk; falling within the watersheds of Severskiy Donets, Dniester, the Black Sea Rivers and the Azov Rivers.

### B) Small hydropower developments

As shown in Figure SW2 and Table 7-2, all areas containing Surface water and Groundwater topic receptors are considered to be of high or medium sensitivity to the small hydropower renewable energy scenario under consideration.

Areas near to surface water are identified as being of ‘high’ sensitivity to the small hydropower development renewable energy scenario under consideration. This is due to potential impacts upon surface water resources and flooding regimes (see Section 8.2.3). With regard to surface water quality, these areas are considered to be of ‘medium’ sensitivity.

As shown in Figure SW2, although a location near to surface water is a requirement for small hydropower development, these areas also present potential spatial constraints that will require particular consideration prior to the implementation of a project to be funded by USELF.

Areas in which more than 25% of total water use is sourced from groundwater are considered to be of 'medium' sensitivity due to potential impacts upon groundwater quality and groundwater resource and may also present spatial constraints.

Areas particularly likely to cause spatial constraints to small hydropower development are described above in Paragraph A.

#### C) Solar photovoltaic developments

As shown in Figure SW3 and Table 7-2, all areas containing Surface water and Groundwater topic receptors are considered to be of 'medium' sensitivity to the solar photovoltaic development renewable energy scenario under consideration (see Section 8.2.3).

Although the solar photovoltaic renewable energy scenario has different technical exclusions, the areas identified as presenting spatial constraints to on-shore wind development are also applicable to solar photovoltaic development (as described in Paragraph A). However, there are notable areas that are relevant for spatial constraints under the solar photovoltaic renewable energy scenario that are not identified for small hydropower, due to the different technical exclusions. These areas include watercourse within the major watersheds of the Dnipro, Southern Buh and Crimean Rivers.

#### D) Biomass developments<sup>2</sup>

As shown in Figure SW4, Figure SW5 and Table 7-2, all areas within Ukraine containing Surface water and Groundwater topic receptors are considered to be of 'medium' sensitivity to the biomass renewable energy scenario under consideration. As the sensitivities for the biomass renewable energy scenario have been assigned the same levels as the on-shore wind renewable energy scenario, the description of spatial constraints given in Paragraph A is also generally applicable. However, the biomass renewable energy scenario has different technical exclusions depending on whether the biomass fuel to be used is derived from agricultural residues or wood residues. These different technical exclusions are shown in Figures SW4 and SW5.

##### i. *Biomass using agricultural residues*

Figure SW4 shows the areas identified as presenting spatial constraints to biomass development using agricultural residues. As well as the surface waters of Ukraine (as described in Paragraph A) parts of the following oblasts also present spatial constraints due to the sensitivity of the groundwater resource and quality: Luhansk, Kharkiv, Donetsk, Zaporizhia, Kherson, Odessa, Vinnytsia, Mykolaiv, Khmelnytskyi, Ternopil, Ivano-Frankivsk, L'viv, and Volyn.

##### ii. *Biomass using wood residues*

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<sup>2</sup> The assessment of 'biomass' sensitivity and spatial constraints analysis incorporates both biomass using wood residues and biomass using agricultural residues.

As shown in Figure SW5 and described further in Section 4.2.5 and Section 7.4, only the following oblasts are suitable for supporting a 5 MW or greater biomass CHP system using wood residues: Chernihiv, Kyiv, Zhytomyr, Sumy, Chernivtsi, Vinnytsia, L'viv, Rivne and Zakarpattia (see also Figure 4-4 which shows the economic potential for wood biomass power generation for each oblast). As detailed in Section 4.2.5, a biomass CHP system should be within 100km of the source of the fuel supply; therefore, the spatial constraints identified for the biomass renewable energy scenario and mapped in Figure SW5 apply within the oblasts listed and also within a 100km buffer of these oblasts. This constraint technically excludes development from within the southern and eastern oblasts and Crimea.

#### E) Biogas developments<sup>3</sup>

As shown in Figure SW6, Figure SW7 and Table 7-2, all areas within Ukraine containing Surface water and Groundwater topic receptors are considered to be of 'medium' sensitivity to the biogas development renewable energy scenario under consideration.

The biogas renewable energy scenario has different technical exclusions depending on whether the biogas is to be derived from animal manure or municipal landfill gas. These different technical exclusions are shown in Figures SW6 and SW7 and described further below.

##### i. *Biogas using animal manure*

Figure SW6 shows that the areas identified as presenting spatial constraints to biomass development using agricultural residues are also applicable to biogas development using animal manure; and the text provided for this in Paragraph Di is therefore applicable.

##### ii. *Biogas using municipal landfill gas*

As shown in Figure SW7 and described further in Section 4.2.6 and Section 7.4, only 25 sites have been investigated for power and heat conversion potential. Therefore, the spatial constraints for the biogas renewable energy scenario only apply to the locations of these 25 sites and their immediate surrounds (up to 10km). The 25 sites are associated with 19 cities which have high populations. These are, in order of population: Kyiv, Kharkiv, Dnipropetrovsk, Odessa, Donetsk, Zaporizhia, L'viv, Mariupol, Luhansk, Vinnytsia, Chernihiv, Sumy, Rivne, Khmelnytskyi, Chernivtsi, Ivano-Frankivsk, Luts'k, Yalta, and Alushta. As shown in Figure SW7, the majority of these potential sites are located near to surface water bodies or groundwaters and are therefore of medium sensitivity to LFG biogas development; however, neither of the sites of the Crimean cities of Alushta and Yalta are identified as sensitive in this respect.

### 3. Geology and soils

#### A) On-shore wind power developments

As shown in Figure GS1 and Table 7-2, there are a number of areas across Ukraine likely to present constraints to on-shore wind power developments. These spatial constraints arise due to the sensitivity of the Geology and Soils topic receptors to on-shore wind power development,

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<sup>3</sup> The assessment of 'biogas' sensitivity and spatial constraints analysis incorporates both biogas using municipal landfill gas and biogas using animal manure.

as well as the technical exclusions which are common to all the on-shore wind development maps (described further in Section 4.2 and Section 7.4).

There are no areas considered to be of ‘high’ sensitivity to the on-shore wind power development renewable energy scenario. Therefore, outside of the technically excluded areas, there are no areas that are likely to present major constraints to the implementation of on-shore wind development with regards to Geology and Soils. However, areas near to high value soils are identified as being of ‘medium’ sensitivity due to potential impacts upon these soils resulting from the on-shore wind power development renewable energy scenario. The areas shown as being potentially sensitive on Figure GS1 are those in which at least 30% of the soil present is recognised as being ‘highly valuable soil’ in the National Atlas of Ukraine. The following oblasts contain particularly large areas with high percentages of ‘highly valuable soils’: Khmelnytskyi, Vinnytsia, Zhytomyr, Kyiv, Cherkasy, Odessa, Kirovohrad, Poltava, Sumy, Kharkiv, Mykolaiv, Kherson, Zaporizhia, and Crimea. It is important to note that there are other areas, not identified in Figure GS1, which contain highly valuable soils that make up less than 30% of the soils present. Further detailed analysis will be required prior to the implementation of an on-shore wind project funded by USELF.

Landslide hazard areas are classified as being of ‘low’ sensitivity, primarily within the Crimean Mountains and the mountainous regions of Southern Crimea. These areas are largely technically excluded from consideration for on-shore wind development.

Of the three Geology and Soils receptors which were not mapped, *Soil Composition* was assessed as being of medium sensitivity to the on-shore wind power development renewable energy scenario; whilst *Bedrock Geology* and *Contaminated Land* were both assessed as being of ‘low’ sensitivity. It was not practicable to map the sensitivities of these receptors. They will be the subject of location-specific analysis prior to the implementation of an on-shore wind project funded by USELF.

#### B) Small hydropower developments

As shown in Figure GS2 and Table 7-2, there are a number of areas within Ukraine which contain Geology and Soils receptors which are sensitive to small hydropower developments.

There are no areas considered to be of ‘high’ sensitivity to the small hydropower scenario.

Areas near to high value soils and landslide hazard areas are identified as being of ‘medium’ sensitivity due to potential impacts upon these soils resulting from the small hydropower development renewable energy scenario. Due to the technical exclusions relevant to small hydropower development, many of the areas containing high value soils and landslide hazard areas are excluded. However, as shown in Figure GS2, there are some areas within which small hydropower development would still be technically feasible, but which would present spatial constraints requiring further investigation. These areas include the oblasts listed in Paragraph A as well as the oblasts of Chernihiv and Dnipropetrovsk and the landslide hazard areas within the Carpathian and Crimean Mountains. Descriptions of sensitivities for the unmapped receptors, are also as described above in Paragraph A.



C) Solar photovoltaic developments

As shown in Figure GS3 and Table 7-2, there are a number of areas within Ukraine which contain Geology and Soils receptors which are sensitive to solar photovoltaic developments.

The sensitivity of the mapped and unmapped Geology and Soils receptors to the solar photovoltaic development renewable energy scenario are identical to those for the on-shore wind development renewable energy scenario, as described in Paragraph A. However, the technical exclusions for the solar photovoltaic development renewable energy scenario are different to those for the on-shore wind development renewable energy scenario. In general, there are fewer areas technically excluded for solar photovoltaic development. Considerably greater areas of land within the oblasts described in Paragraph A are technically feasible for solar photovoltaic development but do present spatial constraints that require further investigation prior to the implementation of a project funded by USELF.

D) Biomass developments

As shown in Figure GS4, Figure GS5 and Table 7-2, there are a number of areas within Ukraine which contain Geology and Soils receptors which are sensitive to biomass developments. As the sensitivity of the mapped and unmapped Geology and Soils receptors to the biomass development renewable energy scenario are identical to those for the on-shore wind development renewable energy scenario, the description of spatial constraints given in Paragraph A is generally applicable. However, the technical exclusions are different for the biomass development renewable energy scenario; and also vary depending on whether the biomass fuel is derived from agricultural residues or wood residues. These different technical exclusions are shown in Figures GS4 and GS5 and described further below.

i. *Biomass using agricultural residues*

Figure GS4 shows the areas identified as presenting spatial constraints to biomass development using agricultural residues. Spatial constraints are presented due to the high percentages of 'highly valuable soil' within all or parts of the following oblasts: Khmelnytskyi, Vinnytsia, Zhytomyr, Kyiv, Cherkasy, Odessa, Kirovohrad, Poltava, Chernihiv, Sumy, Kharkiv, Mykolaiv, Dnipropetrovsk, Kherson, Zaporizhia, and Crimea. Furthermore, landslide hazard areas present spatial constraints to biomass development using agricultural residues within the Carpathian Mountains and Crimean Mountains.

ii. *Biomass using wood residues*

As shown in Figure GS5 and described further in Section 4.2.5 and Section 7.4, only the following oblasts are suitable for supporting a 5 MW or greater biomass CHP system using wood residues: Chernihiv, Kyiv, Zhytomyr, Sumy, Chernivtsi, Vinnytsia, L'viv, Rivne and Zakarpattia (see also Figure 4-4 which shows the economic potential for wood biomass power generation for each oblast). As detailed in Section 4.2.5, a biomass CHP system should be within 100km of the source of the fuel supply; therefore, the spatial constraints identified for the biomass renewable energy scenario and mapped within Figure GS5 apply within the oblasts listed and also within a 100km buffer of these oblasts. This constraint technically excludes development from within the southern and eastern oblasts and Crimea. Furthermore, the medium sensitivity

of the ‘highly valuable soil’ would present some constraint to development within: Khmelnytskyi, Vinnytsia, southern Zhytomyr, southern Kyiv, Cherkasy, northern Odessa, western Kirovohrad, northern Poltava, southern Chernihiv, Sumy, southern Kharkiv and north-eastern Mykolaiv; and the landslide hazard areas present spatial constraints to biomass development using wood residues within the Carpathian Mountains.

E) Biogas developments

As shown in Figure GS6, Figure GS7 and Table 7-2, there are a number of areas within Ukraine which contain Geology and Soils receptors which are sensitive to biogas developments.

The sensitivity of the mapped Geology and Soils receptors – *Landslide Hazard Areas* and *High Value Soils* – to the biogas development renewable energy scenario are identical to those for the on-shore wind development renewable energy scenario, and are therefore as described in Paragraph A. Of the three Geology and Soils receptors which were not mapped, *Soil Composition* and *Contaminated Land* were assessed as being of medium sensitivity to the biogas development renewable energy scenario; whilst *Bedrock Geology* was assessed as being of ‘low’ sensitivity. It was not practicable to map the sensitivities of these receptors. They will be the subject of location-specific analysis prior to the implementation of a biogas project funded by USELF.

The biogas renewable energy scenario has different technical exclusions depending on whether the biogas is to be derived from animal manure or municipal landfill gas. These different technical exclusions are shown in Figures GS6 and GS7 and described further below.

i. *Biogas using animal manure*

Figure GS6 shows that the areas identified as presenting spatial constraints to biomass development using agricultural residues are also applicable to biogas development using animal manure; and the text provided for this in Paragraph Di is applicable.

ii. *Biogas using municipal landfill gas*

As shown in Figure GS7 and described further in Section 4.2.6 and Section 7.4, only 25 sites have been investigated for power and heat conversion potential. Therefore, the spatial constraints for the biogas renewable energy scenario only apply to the locations of these 25 sites and their immediate surrounds (up to 10km). The 25 sites are associated with 19 cities which have high populations. These are, in order of population: Kyiv, Kharkiv, Dnipropetrovsk, Odessa, Donetsk, Zaporizhia, L’viv, Mariupol, Luhansk, Vinnytsia, Chernihiv, Sumy, Rivne, Khmelnytskyi, Chernivtsi, Ivano-Frankivsk, Luts’k, Yalta, and Alushta. Of these sites only Khmelnytskyi, Vinnytsia, Kyiv, Sumy, Kharkiv, Odessa and the two Crimean cities of Alushta and Yalta present potential spatial constraints to LFG biogas development due to the presence of ‘especially valuable soil’.

#### 4. Landscape and biodiversity

A) On-shore wind power developments

As shown in Figure LB1 and Table 7-2, there are a number of areas across Ukraine likely to present constraints to on-shore wind power developments. These spatial constraints arise due to the sensitivity of the Landscape and Biodiversity topic receptors to on-shore wind development, as well as the technical exclusions which are common to all the on-shore wind development maps (described further in Section 4.2 and Section 7.4).

The *Protected Landscapes* and *Protected Biodiversity Areas* of Ukraine (including biosphere reserves, world heritage sites, Ramsar sites, and national parks) as well as the *Unprotected Remnant Natural Ecosystems* (including five types of forest, Yaila and meadows, steppe grassland, river corridors, water permanent wetlands, and steppe savannah) are categorised as being of ‘high’ sensitivity to the on-shore wind power development renewable energy scenario under consideration. Some areas of Ukraine which fall within these categories have been technically excluded from consideration. However, as can be seen from Figure LB1, substantial areas of land have not been technically excluded which would present spatial constraints to on-shore wind power development. These include areas of the Carpathian Mountains, the Dnieper River corridor, and the Crimean Mountains; as well as the Pilisky Nature Reserve, Pripjat Marshes and Red Forest of northern Zhytomyr and northern Kyiv.

The *Aquatic Ecosystems* receptor – which includes Marine Protected Areas, Ramsar Sites and surface waters – is categorised as being of ‘medium’ sensitivity to the on-shore wind power development renewable energy scenario. As well as the legally protected sites, particular areas that are likely to present spatial constraints to this renewable energy scenario are those in close proximity to the major rivers and their tributaries; including, in particular, the Dnipro, the Dniester, the Severskiy Donets and the Azov Rivers.

The *Unprotected Adapted Ecosystems* receptor is of low sensitivity. This receptor presents spatial constraints to all areas of Ukraine that are not technically excluded or coincidental with other Landscape and Biodiversity receptors of greater sensitivity (as shown in Figure LB1).

Three of the Landscape and Biodiversity receptors were not mapped. Of these, *Protected Species* and *High Quality Unregulated Landscapes* were categorised as being of ‘high’ sensitivity; whilst *Low Quality Landscapes* are of ‘medium’ sensitivity. Further, location-specific, analysis will be required for all the Landscape and Biodiversity receptors prior to the implementation of an on-shore wind project funded by USELF.

#### B) Small hydropower developments

As shown in Figure LB2 and Table 7-2, there are a number of areas within Ukraine which contain Landscape and Biodiversity receptors which are sensitive to small hydropower developments. The *Protected Landscapes*, *Protected Biodiversity Areas*, *Unprotected Remnant Natural Ecosystems* and the *Aquatic Ecosystems* receptors are all considered to be of ‘high’ sensitivity to the small hydropower development renewable energy scenario. However, due to the technical exclusions for small hydropower development, only areas associated with the above receptors within 10km of surface waters will require further investigation due to the spatial constraints which they would present to a small hydropower project funded by USELF.

The text provided above in Paragraph A regarding the sensitivities and spatial constraints relevant to the three unmapped Landscape and Biodiversity receptors also applies to the small hydropower development renewable energy scenario.

C) Solar photovoltaic developments

As shown in Figure LB3 and Table 7-2, the sensitivities of the Landscape and Biodiversity receptors to the solar photovoltaic development renewable energy scenario are identical to those for the on-shore wind renewable energy scenario. Therefore the text provided in Paragraph A is also generally applicable. However, the technical exclusions for the solar photovoltaic development renewable energy scenario are different to those for the on-shore wind development renewable energy scenario. In general, there are fewer areas technically excluded for solar photovoltaic development. Considerably greater areas of land within the oblasts described in Paragraph A are technically feasible for solar photovoltaic development but do present spatial constraints that require further investigation prior to the implementation of a project funded by USELF.

D) Biomass developments

As shown in Figure LB4, Figure LB5 and Table 7-2, large areas of Ukraine contain Landscape and Biodiversity receptors which are sensitive to biomass development. The sensitivity of the mapped and unmapped Landscape and Biodiversity receptors to the biomass development renewable energy scenario are identical to those for the on-shore wind renewable energy scenario. Therefore the text in Paragraph A is generally applicable. However, the technical exclusions are different for the biomass development renewable energy scenario; and also vary depending on whether the biomass fuel is derived from agricultural residues or wood residues. These different technical exclusions are shown in Figures LB4 and LB5 and described further below.

i. *Biomass using agricultural residues*

Figure LB4 shows the areas identified as presenting spatial constraints to biomass development using agricultural residues. Spatial constraints are presented due to the high sensitivity of the protected landscapes, protected biodiversity areas, or unprotected remnant natural ecosystems within all or parts of the following oblasts in particular: Zakarpattia, Ivano-Frankivsk, Chernivtsi, Khmelnytskyi, L'viv, Volyn, Rivne, Zhytomyr, Kyiv, Chernihiv, Sumy, Odessa and Crimea; as well as the areas along the main river channels of the Dnipro and Donets Rivers. Further spatial constraints are forecast by the medium sensitivity assigned to Aquatic Ecosystems – including the surface watercourses of Ukraine (as described in Paragraph 2.A).

The *Unprotected Adapted Ecosystems* receptor presents spatial constraints of a low sensitivity to all areas of Ukraine that are not technically excluded or coincidental with other Landscape and Biodiversity receptors of greater sensitivity (as shown in Figure LB4).

ii. *Biomass using wood residues*

As shown in Figure LB5 and described further in Section 4.2.5 and Section 7.4, only the following oblasts are suitable for supporting a 5 MW or greater biomass CHP system using wood residues: Chernihiv, Kyiv, Zhytomyr, Sumy, Chernivtsi, Vinnytsia, L'viv, Rivne and Zakarpattia (see also

Figure 4-4 which shows the economic potential for wood biomass power generation for each oblast). As detailed in Section 4.2.5, a biomass CHP system should be within 100km of the source of the fuel supply; therefore, the spatial constraints identified for the biomass renewable energy scenario and mapped within Figure LB5 apply within the oblasts listed and also within a 100km buffer of these oblasts. This constraint technically excludes development from within the southern and eastern oblasts and Crimea; the description of spatial constraints relating to the remaining areas is as described above in Di.

#### E) Biogas developments

As shown in Figure LB6, Figure LB7 and Table 7-2, the sensitivities of the Landscape and Biodiversity receptors to the biogas development renewable energy scenario are identical to those for the on-shore wind renewable energy scenario. Therefore the text in Paragraph A is also generally applicable. However, the biogas renewable energy scenario has different technical exclusions depending on whether the biogas is to be derived from animal manure or municipal landfill gas. These different technical exclusions are shown in Figures LB6 and LB7 and described further below.

##### i. *Biogas using animal manure*

Figure LB6 shows that the areas identified as presenting spatial constraints to biomass development using agricultural residues are also applicable to biogas development using animal manure and therefore the text provided for this in Paragraph Di is generally applicable; however, it should be noted that for biogas using animal manure the 'unprotected remnant natural ecosystems' receptor is identified as being of medium sensitivity (rather than high).

##### ii. *Biogas using municipal landfill gas*

As shown in Figure LB7 and described further in Section 4.2.6 and Section 7.4, only 25 sites have been investigated for power and heat conversion potential. Therefore, the spatial constraints for the biogas renewable energy scenario only apply to the locations of these 25 sites and their immediate surrounds (up to 10km). The 25 sites are associated with 19 cities which have high populations. These are, in order of population: Kyiv, Kharkiv, Dnipropetrovsk, Odessa, Donetsk, Zaporizhia, L'viv, Mariupol, Luhansk, Vinnytsia, Chernihiv, Sumy, Rivne, Khmelnytskyi, Chernivtsi, Ivano-Frankivsk, Luts'k, Yalta, and Alushta. All of these sites will present potential spatial constraints to LFG biogas development due to the presence of receptors identified as being sensitive, as shown in Figure LB7.

## 5. Community and socio-economics

#### A) On-shore wind power developments

As shown in Figure CS1 and Table 7-2, there are a number of areas across Ukraine likely to present constraints to on-shore wind power developments. These spatial constraints arise due to the sensitivity of the Community and Socio-economic topic receptors to on-shore wind power development, as well as the technical exclusions which are common to all the on-shore wind development maps (described further in Section 4.2 and Section 7.4).

There are no areas considered to be of ‘high’ sensitivity to the on-shore wind power development renewable energy scenario under consideration. Therefore, outside of the technically excluded areas, there are no areas that are likely to present major constraints to the implementation of on-shore wind development with regards to Community and Socio-economics. However, Urban areas and their immediate surrounds have been identified as being of ‘medium’ sensitivity to the *Health* receptor; and therefore those urban areas that are not technically excluded would present spatial constraints to on-shore wind development (see Figure CS1).

Urban areas are considered to be of greater sensitivity to health effects due to the higher baseline health pressures that exist within urban areas, such as noise and dust. Such pressures would be compounded by additional sources arising from the on-shore wind power development renewable energy scenario. However, it is important to note that potential health effects are also important in rural areas. Further analysis of potential spatial constraints associated with health (within both rural and urban areas) would be required prior to the implementation of an on-shore wind project funded by USELF. *Infrastructure* is also identified as being a receptor of ‘medium’ sensitivity. Figure CS1 only shows the major infrastructure of Ukraine and its immediate surrounds; however it is important to note that all infrastructure is potentially sensitive to on-shore wind development.

Based upon the above assumptions, technical exclusions and sensitivity assessments, the following areas in particular are likely to present spatial constraints to on-shore wind power development: the major conurbations of Kyiv, L’viv, Dnipropetrovsk, Kharkiv, Poltava and Luhansk; and the stretches of the major rail lines running between Kyiv and Crimea, Odessa, Donetsk, Kharkiv, Lvi’v and Chernivtsi and stretches of the major road networks serving the country which are not technically excluded (as shown in Figure CS1).

Figure CS1 also shows a number of oblasts which host greater than 2% of the national turnover of tourists and in which development of on-shore wind is assumed to be technically feasible. The *Tourism and Environmental Amenities* receptor is categorised as ‘low’ sensitivity to the on-shore wind power development renewable energy scenario. These oblasts should be considered further for the spatial constraints they may present to the development of an on-shore wind project funded by USELF: Zakarpattia, Ivano-Frankivsk, L’viv, Volyn, Khmelnytskyi, Odessa, Kharkiv, Dnipropetrovsk, Donetsk, Zaporizhia, Kherson, and Crimea. Although these oblasts have been identified as the most likely to be sensitive for this receptor, it is important to note that many of the other oblasts of Ukraine contain areas that are of importance for tourism and environmental amenity.

All three of the Community and Socio-economics receptors that were not mapped (*Demographics, Employment/Earning and Economic Sectors*) have been categorised as being of ‘medium’ sensitivity. It was not practicable to map these receptors in a meaningful way due to the potential for each of these receptors to be sensitive to all areas of Ukraine. As with all topic area, further analysis of potential constraints associated with the Community and Socio-economic receptors (mapped and unmapped) would be required prior to the implementation of an on-shore wind project funded by USELF.

### B) Small hydropower developments

As shown in Figure CS2 and Table 7-2, there are considerable areas of Ukraine which contain Community and Socio-economics receptors which are sensitive to small hydropower developments.

There are no areas considered to be of ‘high’ sensitivity to the small hydropower development renewable energy scenario under consideration.

Urban areas and their immediate surrounds have been identified as being of ‘medium’ sensitivity for the *Health* receptor. *Infrastructure* is also identified as being a receptor of ‘medium’ sensitivity. Furthermore, the *Tourism and Environmental Amenities* receptor has been categorised as ‘medium’ sensitivity for those oblasts listed above in Paragraph A. Due to the technical exclusions relevant to small hydropower development, some areas containing Community and Socio-economic receptors are excluded. However there are many areas within which small hydropower development would still be technically feasible, but which would present spatial constraints requiring further investigation. These areas are generally as described in Paragraph A and are shown in Figure CS2. Descriptions of sensitivities for the unmapped receptors are as described in Paragraph A.

### C) Solar photovoltaic developments

As shown in Figure CS3 and Table 7-2, the sensitivities of the mapped and unmapped Community and Socio-economics receptors to the solar photovoltaic development renewable energy scenario are identical to those for the on-shore wind development renewable energy scenario, as described in Paragraph A. However, the technical exclusions for the solar photovoltaic development renewable energy scenario are different to those for the on-shore wind development renewable energy scenario. This means that there are significant areas of Ukraine technically excluded from solar photovoltaic development; including most of the mountainous regions of the Carpathians and Crimea. In addition to those areas and oblasts discussed in Paragraph A, considerably greater areas of land (within and around those oblasts) are technically feasible for solar photovoltaic development and present spatial constraints that require further investigation prior to the implementation of a project funded by USELF (as shown in Figure CS3).

### D) Biomass developments

As shown in Figure CS4, Figure CS5 and Table 7-2, large areas of Ukraine contain Community and Socio-economics receptors which are sensitive to biomass development. The sensitivity of the mapped and unmapped Community and Socio-economics receptors to the biomass development renewable energy scenario are identical to those for the small hydropower development renewable energy scenario. Therefore the text in Paragraph B is generally applicable. However, the technical exclusions are different for the biomass development renewable energy scenario; and also vary depending on whether the biomass fuel is derived from agricultural residues or wood residues. These different technical exclusions are shown in Figures CS4 and CS5 and described further below.

#### *i. Biomass using agricultural residues*

Figure CS4 shows the areas identified as presenting spatial constraints to biomass development using agricultural residues. Spatial constraints are presented, due to the medium sensitivity of the Community and Socio-economics receptors, in the key tourist oblasts of: Zakarpattia, Ivano-Frankivsk, L'viv, Volyn, Khmelnytskyi, Odessa, Kharkiv, Dnipropetrovsk, Donetsk, Zaporizhia, Kherson, and Crimea; the major conurbations of Kyiv, L'viv, Dnipropetrovsk, Kharkiv, Sumy, Chernihiv, Kirovohrad, Mykolaiv, Poltava and Luhansk; the stretches of the major rail lines running between Kyiv and Crimea, Odessa, Donetsk, Kharkiv, Lvi'v and Chernivtsi; and the stretches of the major road networks serving the country (as shown in Figure CS4).

### ii. *Biomass using wood residues*

As shown in Figure CS5 and described further in Section 4.2.5 and Section 7.4, only the following oblasts are suitable for supporting a 5 MW or greater biomass CHP system using wood residues: Chernihiv, Kyiv, Zhytomyr, Sumy, Chernivtsi, Vinnytsia, L'viv, Rivne and Zakarpattia (see also Figure 4-4 which shows the economic potential for wood biomass power generation for each oblast). As detailed in Section 4.2.5, a biomass CHP system should be within 100km of the source of the fuel supply; therefore, the spatial constraints identified for the biomass renewable energy scenario and mapped within Figure CS5 apply within the oblasts listed and also within a 100km buffer of these oblasts. This constraint technically excludes development from within the southern and eastern oblasts and Crimea; the description of spatial constraints relating to the remaining areas is as described above in Di.

### E) Biogas developments

As shown in Figure CS6, Figure CS7 and Table 7-2, the sensitivities of the Community and Socio-economics receptors to the biogas development renewable energy scenario are identical to those for the on-shore wind development renewable energy scenario. Therefore the text in Paragraph A is also generally applicable. However, the biogas renewable energy scenario has different technical exclusions depending on whether the biogas is to be derived from animal manure or municipal landfill gas. These different technical exclusions are shown in Figures CS6 and CS7 and described further below.

### i. *Biogas using animal manure*

Figure CS6 shows that the areas identified as presenting spatial constraints to biomass development using agricultural residues are also applicable to biogas development using animal manure; and the text provided for this in Paragraph Di is therefore applicable; although it should be noted that tourism is assessed as being of low sensitivity to biogas using animal manure (as opposed to medium).

### ii. *Biogas using municipal landfill gas*

As shown in Figure CS7 and described further in Section 4.2.6 and Section 7.4, only 25 sites have been investigated for power and heat conversion potential. Therefore, the spatial constraints for the biogas renewable energy scenario only apply to the locations of these 25 sites and their immediate surrounds (up to 10km). The 25 sites are associated with 19 cities which have high populations. These are, in order of population: Kyiv, Kharkiv, Dnipropetrovsk, Odessa, Donetsk, Zaporizhia, L'viv, Mariupol, Luhansk, Vinnytsia, Chernihiv, Sumy, Rivne, Khmelnytskyi, Chernivtsi, Ivano-Frankivsk, Luts'k, Yalta, and Alushta. All of these sites will present potential



spatial constraints to LFG biogas development due to the presence of receptors identified as being sensitive, as shown in Figure CS7.

## 6. Cultural heritage

### A) On-shore wind power developments

As shown in Figure CH1 and Table 7-2, there are a number of areas across Ukraine likely to present spatial constraints to on-shore wind power developments. These spatial constraints arise due to the sensitivity of the Cultural Heritage topic receptors to on-shore wind power development, as well as the technical exclusions which are common to all the on-shore wind development maps (described further in Section 4.2 and Section 7.4).

It has only been practicable to map UNESCO World Heritage Sites and sites on the UNSECO Tentative List. These areas are considered to be of 'high' sensitivity to the on-shore wind power development renewable energy scenario under consideration. Some of these Sites are located within the technically excluded areas and are therefore not considered for their spatial constraints. Outside of the technically excluded areas for on-shore wind development, UNESCO World Heritage Sites and sites on the UNESCO Tentative List are located within the following oblasts: the central oblast of Cherkasy; the western oblasts of L'viv, Zakarpattia and Ivano-Frankivsk; and the southwestern oblasts of Ternopil and Khmelnytskyi. The presence of these Sites within the technically feasible areas will be a potential spatial constraint requiring further investigation for any project seeking to develop on-shore wind power in these areas with funding by USELF.

It has not been possible to map the potential spatial constraints presented by the remaining three Cultural Heritage receptors (Registered cultural heritage sites; Unknown or unregistered cultural heritage sites; and Intangible cultural heritage). However, it is important to consider the spatial constraints that the varying sensitivities of these receptors to on-shore wind power development could present.

The locations of *Registered Cultural Heritage Sites* are wide ranging, but recorded (as shown in Figure 3-34 of the SER Topic Paper). Kyiv and the oblast of L'viv are of particular significance as they both contain more than 6% of the overall number of Sites of National Importance within Ukraine. Although portions of these oblasts are technically excluded, there are still large areas that are technically feasible and would present spatial constraints. The following oblasts each contain between 4.1 and 6% of the overall number of Sites of National Importance; and are also of importance: Ternopil; Khmelnytsky; Vinnytsia; Volyn; Chernihiv; and Crimea. Therefore, in addition to the areas shown in Figure CH1 the oblasts mentioned above all have the potential to present Cultural Heritage spatial constraints to the development of the on-shore wind power renewable energy scenario under consideration. However, it should be noted that Chernihiv and Crimea both have a notably large amount of area technically excluded from on-shore wind power development.

Due to their nature, there are no spatial records for the other two Cultural Heritage receptors; however, it is reasonable to assume that *Unknown or unregistered cultural heritage sites* and *Intangible Cultural Heritage* (such as practices and traditions; knowledge and skills; values;

associated objects, artefacts, instruments; and cultural spaces for the above) are more likely to occur in the areas described above. It would be possible, and recommended, to investigate potential constraints associated with such cultural heritage receptors through environmental and social study prior to the implementation of any on-shore wind development project funded by USELF.

#### B) Small hydropower developments

As shown in Figure CH2 and Table 7-2, the sensitivity classifications for the mapped and unmapped Cultural Heritage receptors to the small hydropower development renewable energy scenario are identical to those for the on-shore wind development renewable energy scenario; as described above in Paragraph A. However, the technical exclusions for the small hydropower development renewable energy scenario are different to those for the on-shore wind development renewable energy scenario. Outside of the technically excluded areas for small hydropower development, UNESCO World Heritage Sites and sites on the UNESCO Tentative List are located within the following oblasts: the central oblasts of Kyiv, Cherkasy and Chernihiv; the western oblasts of L'viv and Zakarpattia; the southwestern oblasts of Chernivtsi, Ternopil and Khmelnytskyi; the southern oblast of Odessa; and Crimea. The presence of these Sites within the technically feasible areas will be a potential spatial constraint requiring further investigation for any project seeking to develop small hydropower in these areas with funding by USELF.

The information discussed in Paragraph A regarding *Registered Cultural Heritage Sites*, *Unknown or Unregistered Cultural Heritage Sites* and *Intangible Cultural Heritage* is also applicable to the small hydropower development renewable energy scenario.

#### C) Solar photovoltaic developments

As shown in Figure CH2 and Table 7-2, the sensitivity classifications for the mapped and unmapped Cultural Heritage receptors to the solar photovoltaic development renewable energy scenario are identical to those for the on-shore wind development renewable energy scenario; as described in Paragraph A. However, the technical exclusions for the solar photovoltaic development renewable energy scenario are different to those for the on-shore wind development renewable energy scenario. Outside of the technically excluded areas for solar photovoltaic development, UNESCO World Heritage Sites and sites on the UNESCO Tentative List are located within the following oblasts: the central oblasts of Kyiv, Cherkasy and Chernihiv; the western oblasts of L'viv, Zakarpattia and Ivano-Frankivsk; the southwestern oblasts of Chernivtsi, Ternopil and Khmelnytskyi; the southern oblasts of Odessa and Kherson; and Crimea. The presence of these Sites within the technically feasible areas will be a potential spatial constraint requiring further investigation for any project seeking to develop solar photovoltaic development in these areas with funding by USELF.

The information discussed in Paragraph A regarding *Registered Cultural Heritage Sites*, *Unknown or Unregistered Cultural Heritage Sites* and *Intangible Cultural Heritage* is also applicable to the solar photovoltaic development renewable energy scenario. However, it

should be noted that the oblasts of Ternopil, Khmelnytsky, and Vinnytsia all have a notably large areas technically excluded from solar photovoltaic development.

#### D) Biomass developments

As shown in Figure CH4, Figure CH5 and Table 7-2, there are a number of areas within Ukraine which contain Cultural Heritage receptors which are sensitive to biomass developments. It has only been practicable to map UNESCO World Heritage Sites and sites on the UNSECO Tentative List. These areas are considered to be of 'medium' sensitivity to the biomass development renewable energy scenario under consideration.

The technical exclusions for the biomass renewable energy scenario are different depending on whether the biomass fuel is derived from agricultural residues or wood residues. These different technical exclusions are shown in Figures CH4 and CH5 and described further below.

##### i. *Biomass using agricultural residues*

Figure CH4 shows the areas identified as presenting spatial constraints to biomass development using agricultural residues. Outside of the technically excluded area for biomass development (the Chernobyl Exclusion Zone), UNESCO World Heritage Sites and sites on the UNESCO Tentative List are located within the following oblasts: the central oblasts of Kyiv, Cherkasy and Chernihiv; the western oblasts of L'viv, Zakarpattia and Ivano-Frankivsk; the southwestern oblasts of Chernivtsi, Ternopil and Khmelnytskyi; the southern oblasts of Odessa and Kherson; and Crimea. The presence of these Sites within the technically feasible areas will be a potential spatial constraint requiring further investigation for any project seeking biomass development in these areas with funding by USELF.

The information discussed in Paragraph A regarding *Registered Cultural Heritage Sites, Unknown or Unregistered Cultural Heritage Sites* and *Intangible Cultural Heritage* is also applicable to biomass using agricultural residues; although the technically excluded area for biomass using agricultural residues is significantly less, as it only consists of the Chernobyl Exclusion Zone.

##### ii. *Biomass using wood residues*

As shown in Figure CH5 and described further in Section 4.2.5 and Section 7.4, only the following oblasts are suitable for supporting a 5 MW or greater biomass CHP system using wood residues: Chernihiv, Kyiv, Zhytomyr, Sumy, Chernivtsi, Vinnytsia, L'viv, Rivne and Zakarpattia (see also Figure 4-4 which shows the economic potential for wood biomass power generation for each oblast). As detailed in Section 4.2.5, a biomass CHP system should be within 100km of the source of the fuel supply; therefore, the spatial constraints identified for the biomass renewable energy scenario and mapped within Figure CH5 apply within the oblasts listed and also within a 100km buffer of these oblasts. This constraint technically excludes development from within the southern and eastern oblasts and Crimea. Of the remaining oblasts, the central oblasts of Kyiv, Cherkasy and Chernihiv; the western oblasts of L'viv, Zakarpattia and Ivano-Frankivsk; the southwestern oblasts of Chernivtsi, Ternopil and Khmelnytsky all contain UNESCO World Heritage Sites and sites on the UNESCO Tentative List.

The information discussed in Paragraph A regarding *Registered Cultural Heritage Sites, Unknown or Unregistered Cultural Heritage Sites* and *Intangible Cultural Heritage* is also applicable to biomass using wood residues. The oblasts of Kyiv and L'viv are of particular significance as they both contain more than 6% of the overall number of Sites of National Importance within Ukraine and are technically feasible for biomass development using wood residues; as are the oblasts of Vinnytsia and Chernihiv, which contain between 4.1 and 6% of the overall number of Sites of National Importance.

#### E) Biogas developments

As shown in Figure CH6, Figure CH7 and Table 7-2, the sensitivity classification for the mapped Cultural Heritage receptor (*UNESCO World Heritage Sites and sites on the UNESCO Tentative List*) is the same under the biogas development renewable energy scenario as it is under the biomass development renewable energy scenario. Therefore, the text in Paragraph D is also generally applicable. However, the biogas renewable energy scenario has different technical exclusions depending on whether the biogas is to be derived from animal manure or municipal landfill gas. These different technical exclusions are shown in Figures CH6 and CH7 and described further below.

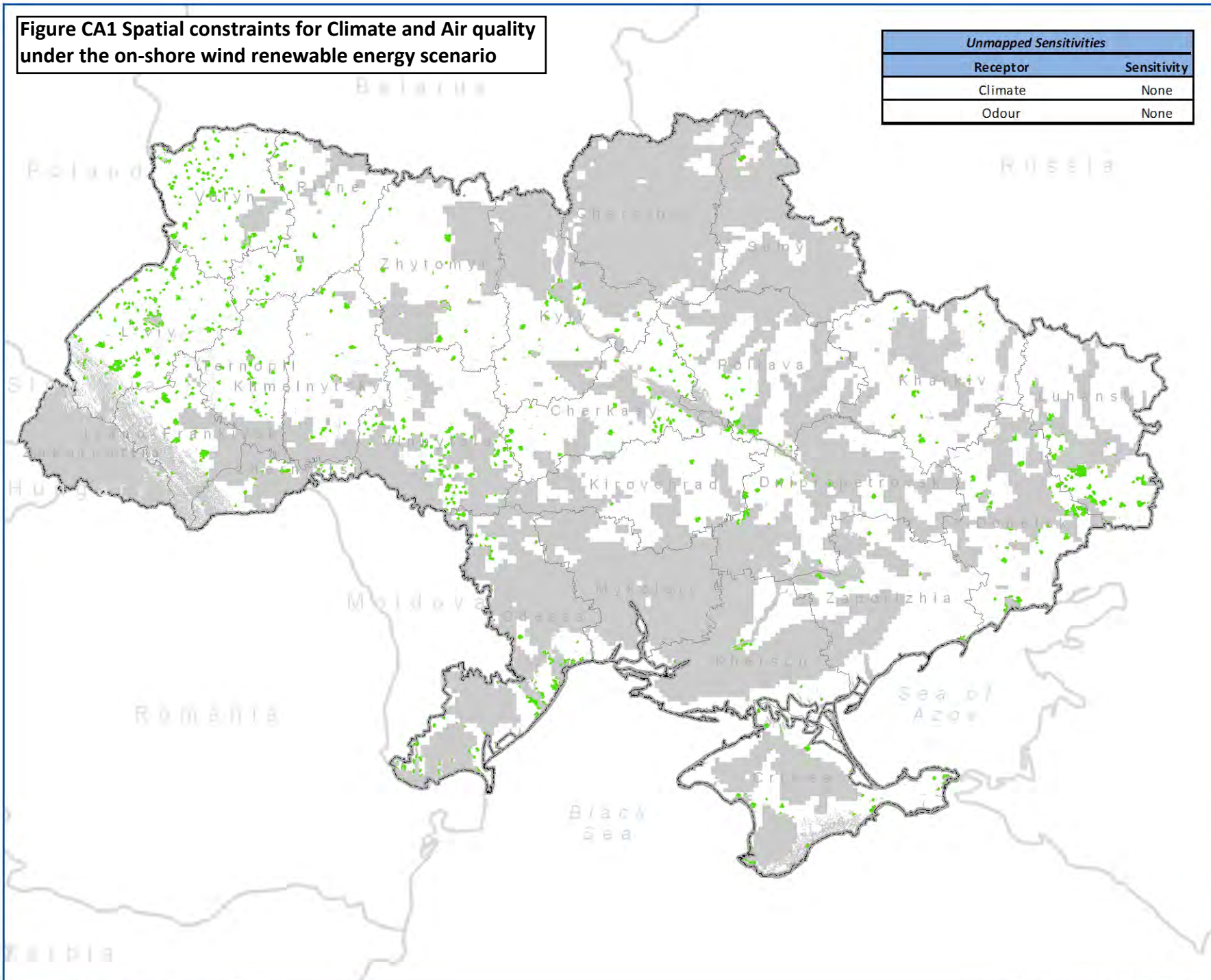
##### i. *Biogas using animal manure*

Figure CH6 shows that the areas identified as presenting spatial constraints to biomass development using agricultural residues are also applicable to biogas development using animal manure; and the text provided for this in Paragraph Di is applicable.

##### ii. *Biogas using municipal landfill gas*

As shown in Figure CH7 and described further in Section 4.2.6 and Section 7.4, only 25 sites (associated with 19 cities which have high populations) have been investigated for power and heat conversion potential. Therefore, spatial constraints analysis only applies to the locations of these 25 sites and their immediate surrounds (up to 10km). Of the sites within the 19 cities, those in the following locations are considered most likely to present spatial constraints due to the presence of UNESCO World Heritage Sites and sites on the UNESCO Tentative List: Kyiv, Odessa, L'viv, Chernihiv, Chernivtsi (as shown in Figure CH7). However, the sites at Vinnytsia, Khmelnytskyi, Ivano-Frankivsk, Luts'k (Volyn), Yalta and Alushta (both in Crimea) also have the potential to present spatial constraints due to the presence of greater than 4% of the overall number of Sites of National Importance within these oblasts.

**Figure CA1 Spatial constraints for Climate and Air quality under the on-shore wind renewable energy scenario**



Unmapped Sensitivities	
Receptor	Sensitivity
Climate	None
Odour	None

**Ukraine Sustainable Energy Lending Facility Strategic Environmental Review**  
**Air Quality and Climate Sensitivity to Wind Development**

**Legend**

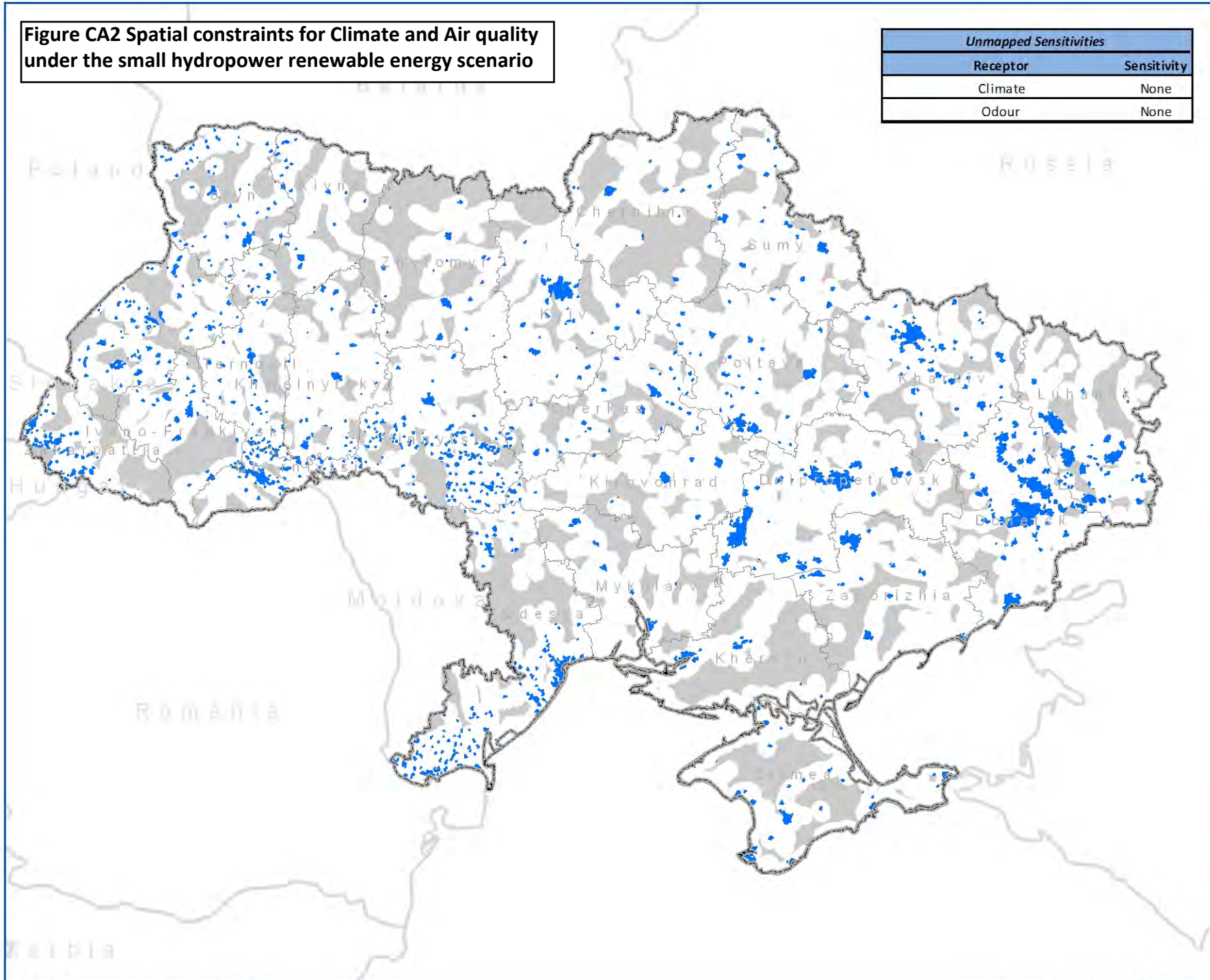
- Technical Exclusions
- Sensitivity**
  - Low
  - Medium
  - High

N  
W E  
S

0 50 100  
Kilometers  
1 cm = 60 km



**Figure CA2 Spatial constraints for Climate and Air quality under the small hydropower renewable energy scenario**



Unmapped Sensitivities	
Receptor	Sensitivity
Climate	None
Odour	None

**Ukraine Sustainable Energy Lending Facility Strategic Environmental Review**

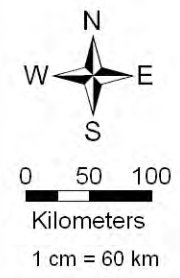
**Air Quality and Climate Sensitivity to Small Hydro Development**

**Legend**

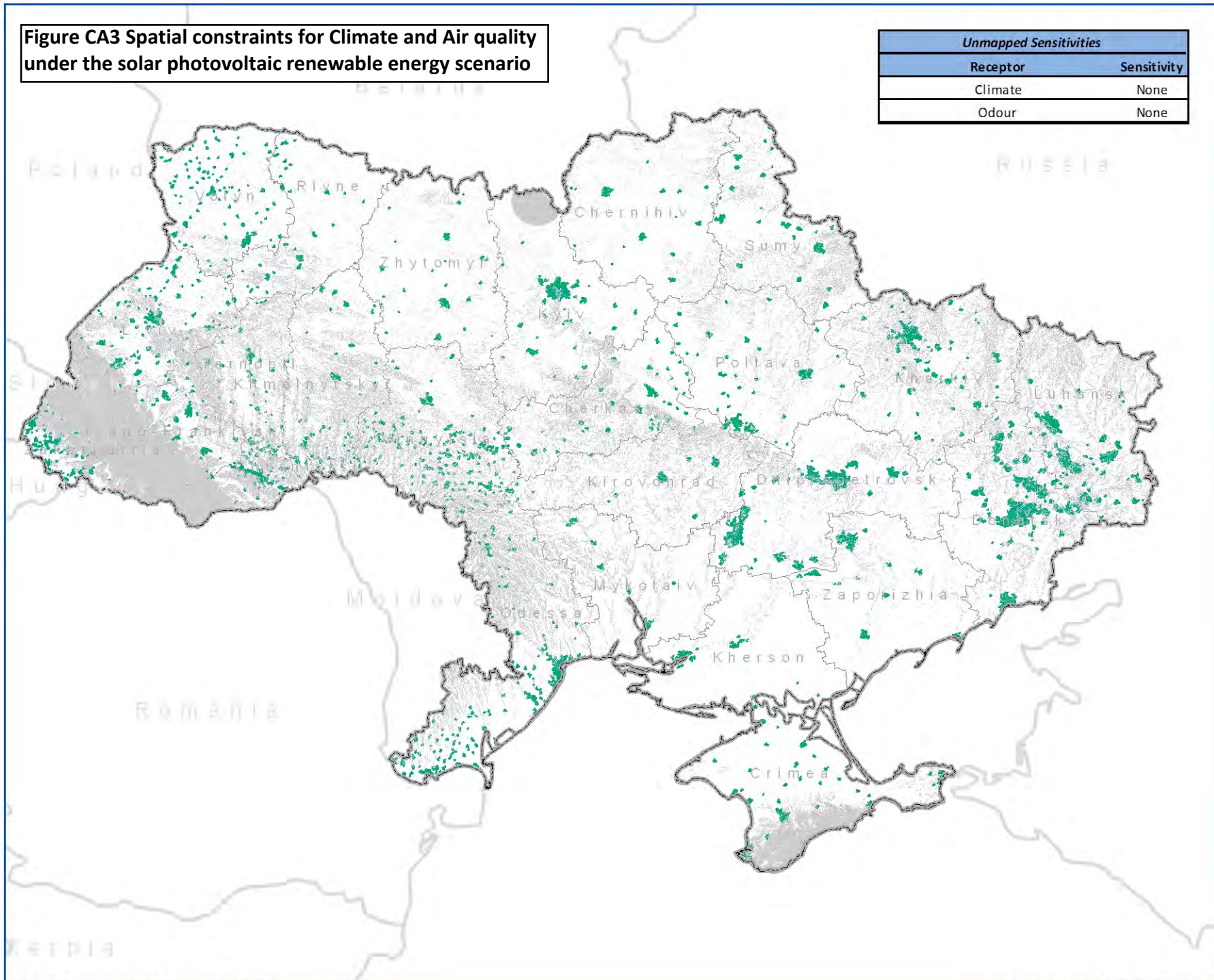
- Technical Exclusions

**Sensitivity**

- Low
- Medium
- High



**Figure CA3 Spatial constraints for Climate and Air quality under the solar photovoltaic renewable energy scenario**



Unmapped Sensitivities	
Receptor	Sensitivity
Climate	None
Odour	None

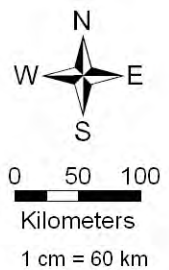
**Ukraine Sustainable Energy Lending Facility Strategic Environmental Review**  
**Air Quality and Climate Sensitivity to Solar Development**

**Legend**

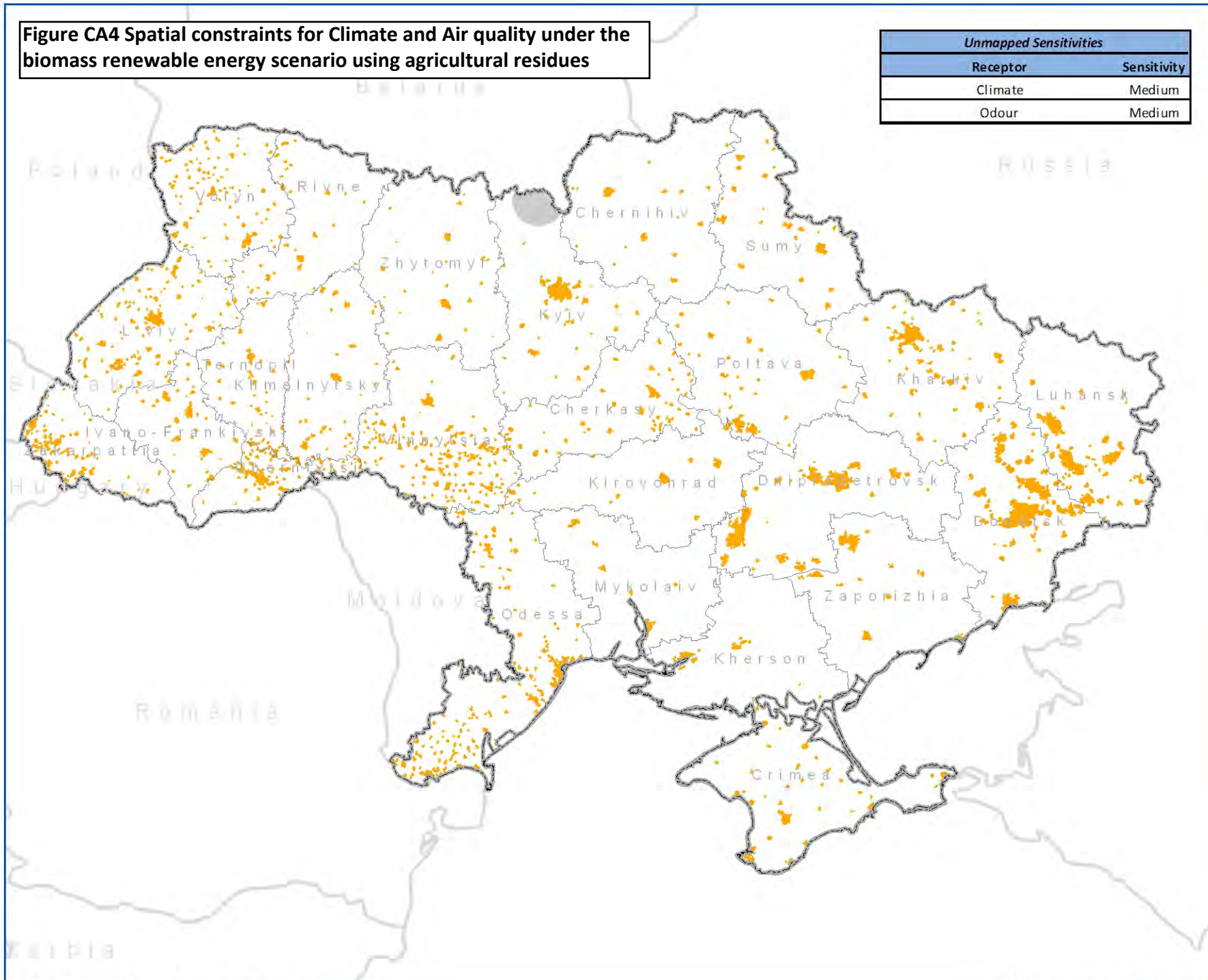
- Technical Exclusions

**Sensitivity**

- Low
- Medium
- High



**Figure CA4 Spatial constraints for Climate and Air quality under the biomass renewable energy scenario using agricultural residues**

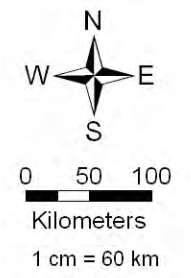


Unmapped Sensitivities	
Receptor	Sensitivity
Climate	Medium
Odour	Medium

**Ukraine Sustainable Energy Lending Facility Strategic Environmental Review  
Air Quality and Climate Sensitivity to Agricultural Residues Biomass Development**

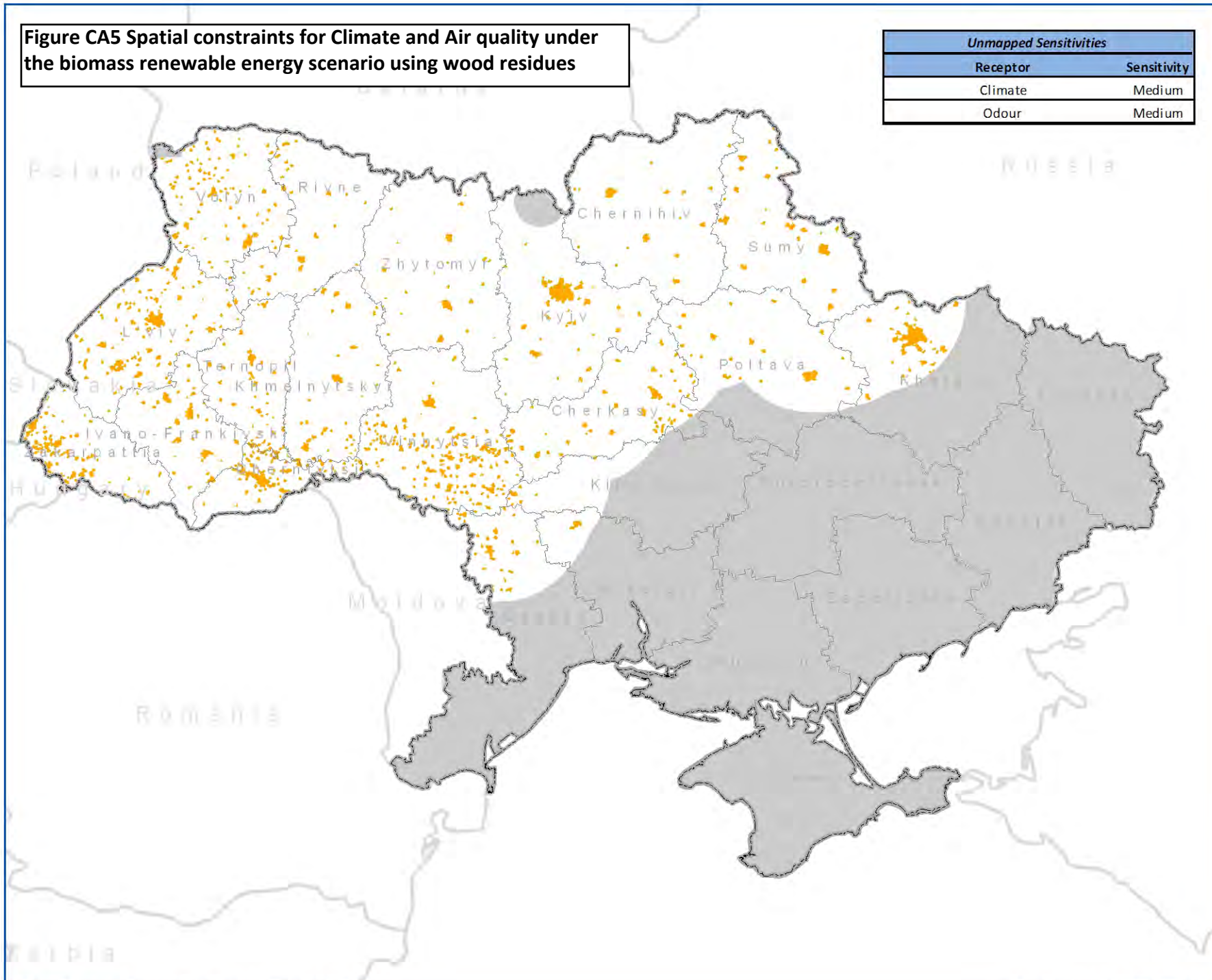
**Legend**

- Technical Exclusion
- Sensitivity**
  - Low
  - Medium
  - High





**Figure CA5 Spatial constraints for Climate and Air quality under the biomass renewable energy scenario using wood residues**



Unmapped Sensitivities	
Receptor	Sensitivity
Climate	Medium
Odour	Medium

**Ukraine Sustainable Energy Lending Facility Strategic Environmental Review**

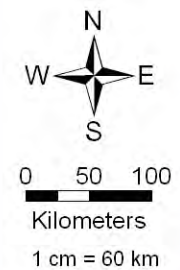
**Air Quality and Climate Sensitivity to Wood Residues Biomass Development**

**Legend**

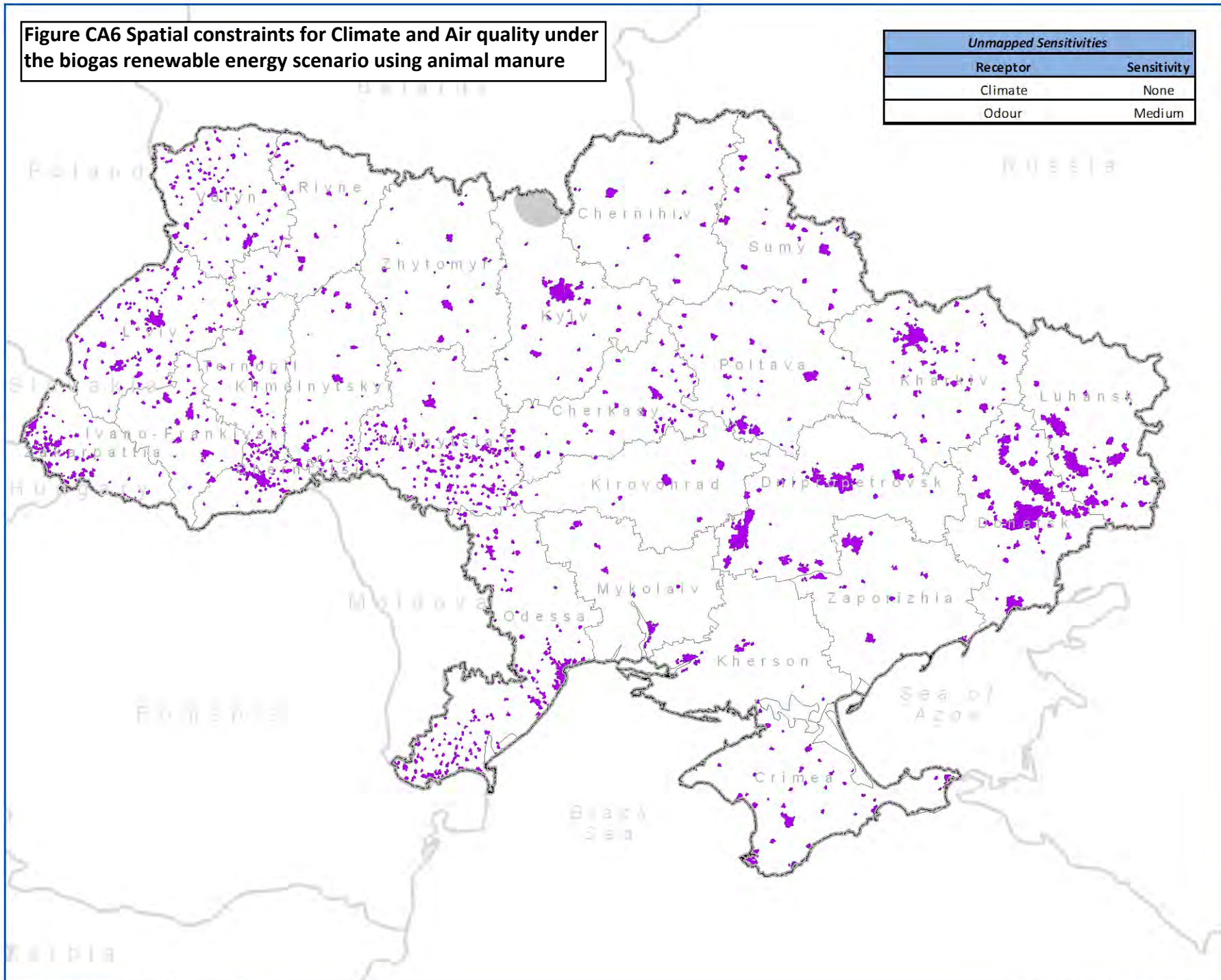
- Technical Exclusion

**Sensitivity**

- Low
- Medium
- High



**Figure CA6 Spatial constraints for Climate and Air quality under the biogas renewable energy scenario using animal manure**



Unmapped Sensitivities	
Receptor	Sensitivity
Climate	None
Odour	Medium

**Ukraine Sustainable Energy Lending Facility Strategic Environmental Review**  
**Air Quality and Climate Sensitivity to Animal Manure Biogas Development**

**Legend**

- Technical Exclusion

**Sensitivity**

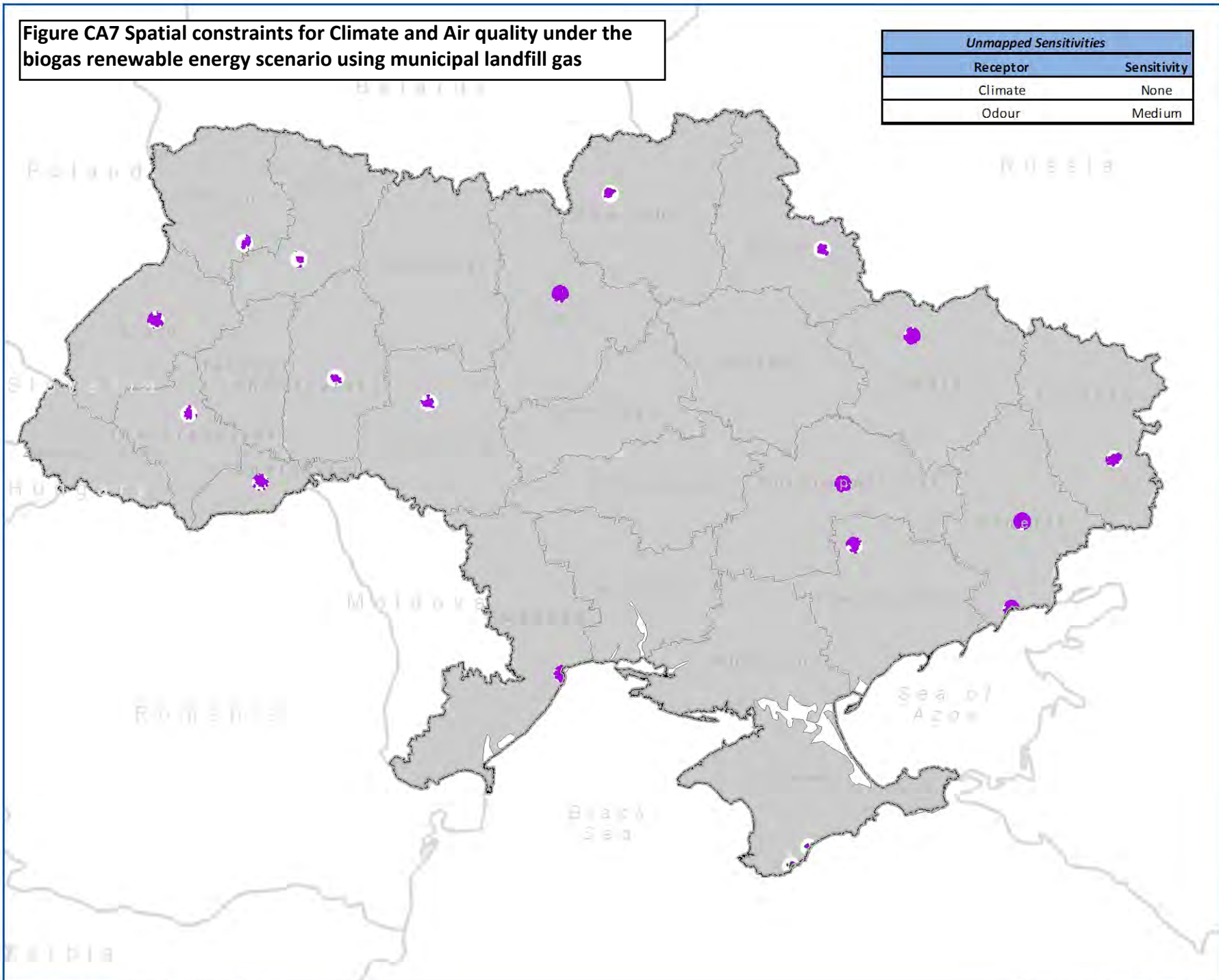
- Low
- Medium
- High

0 50 100  
Kilometers  
1 cm = 60 km

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**BLACK & VEATCH**  
Building a world of difference:

**Figure CA7 Spatial constraints for Climate and Air quality under the biogas renewable energy scenario using municipal landfill gas**



**Ukraine Sustainable Energy Lending Facility Strategic Environmental Review**  
**Air Quality and Climate Sensitivity to Landfill Gas Biogas Development**

**Legend**

- Technical Exclusion

**Sensitivity**

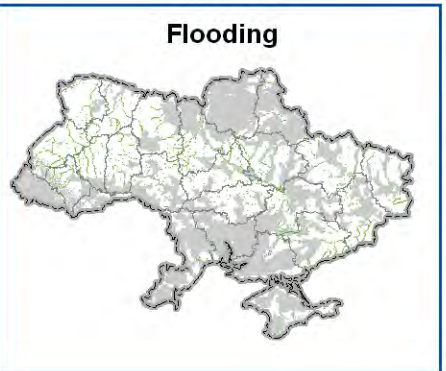
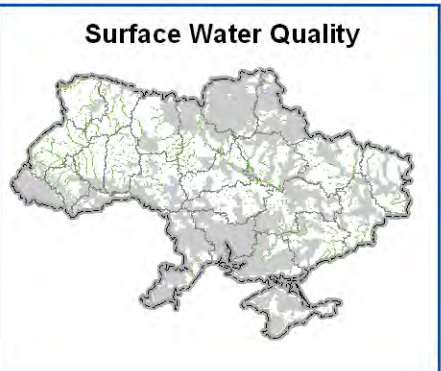
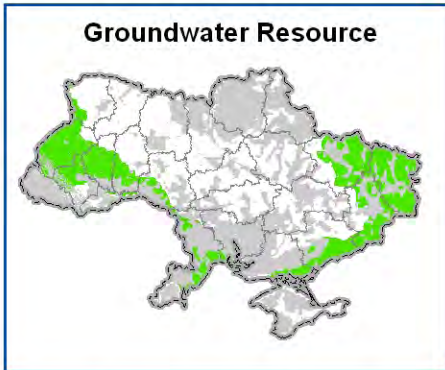
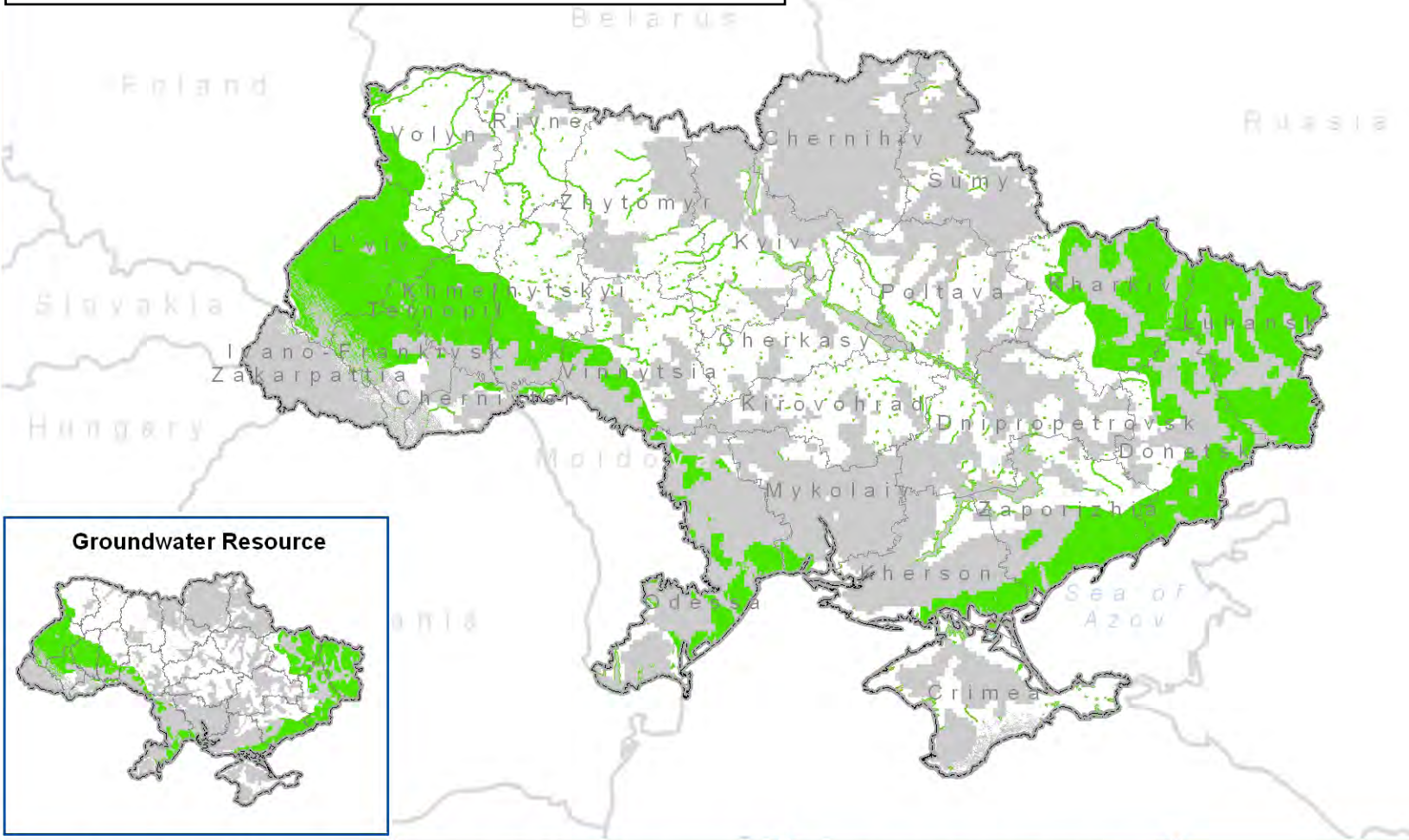
- Low
- Medium
- High

0 50 100  
Kilometers  
1 cm = 60 km

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**Figure SW1 Spatial constraints for Surface water and Groundwater under the on-shore wind renewable energy scenario**



**Surface and Groundwater Sensitivity to Wind Development**

- Legend**
- Technical Exclusions
  - Sensitivity**
  - Low
  - Medium
  - High

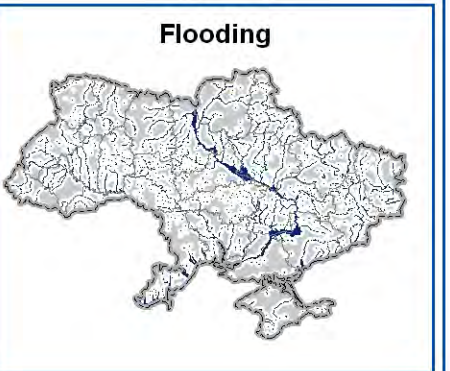
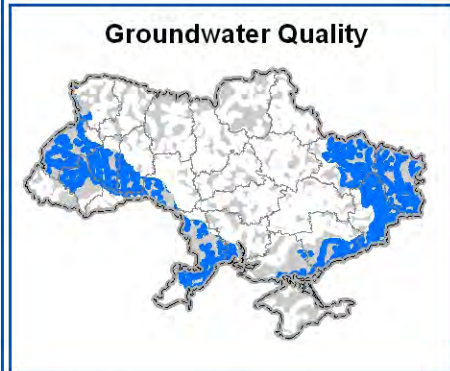
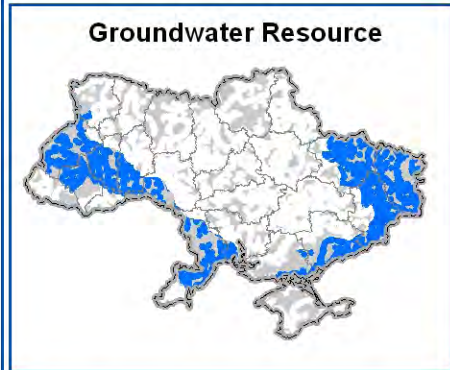
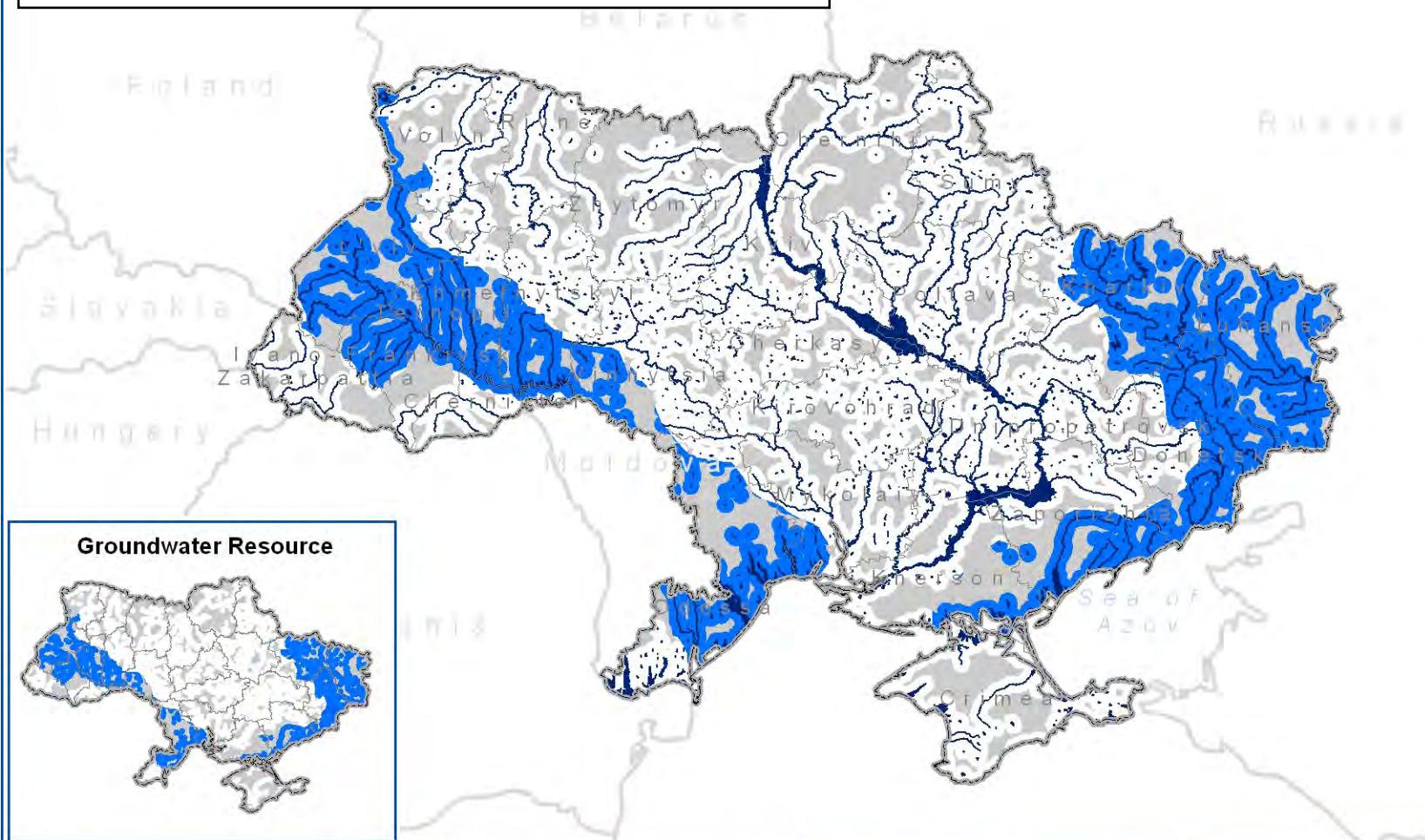
Data Sources: National Atlas of Ukraine; DeLorme; ArcWorld Supplement



0 50 100  
Kilometers  
1 cm = 80 km



**Figure SW2 Spatial constraints for Surface water and Groundwater under the small hydropower renewable energy scenario**



**Surface and  
Groundwater  
Sensitivity to  
Small Hydro  
Development**

- Legend**
- Technical Exclusions
  - Sensitivity**
    - Low
    - Medium
    - High

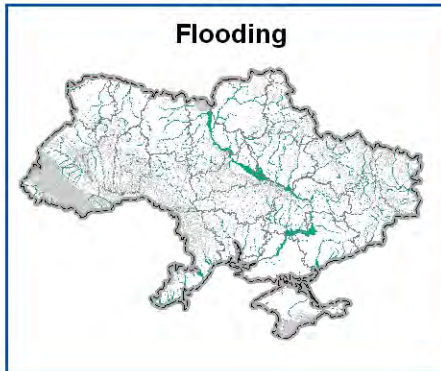
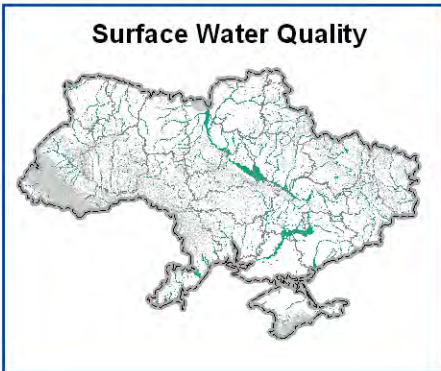
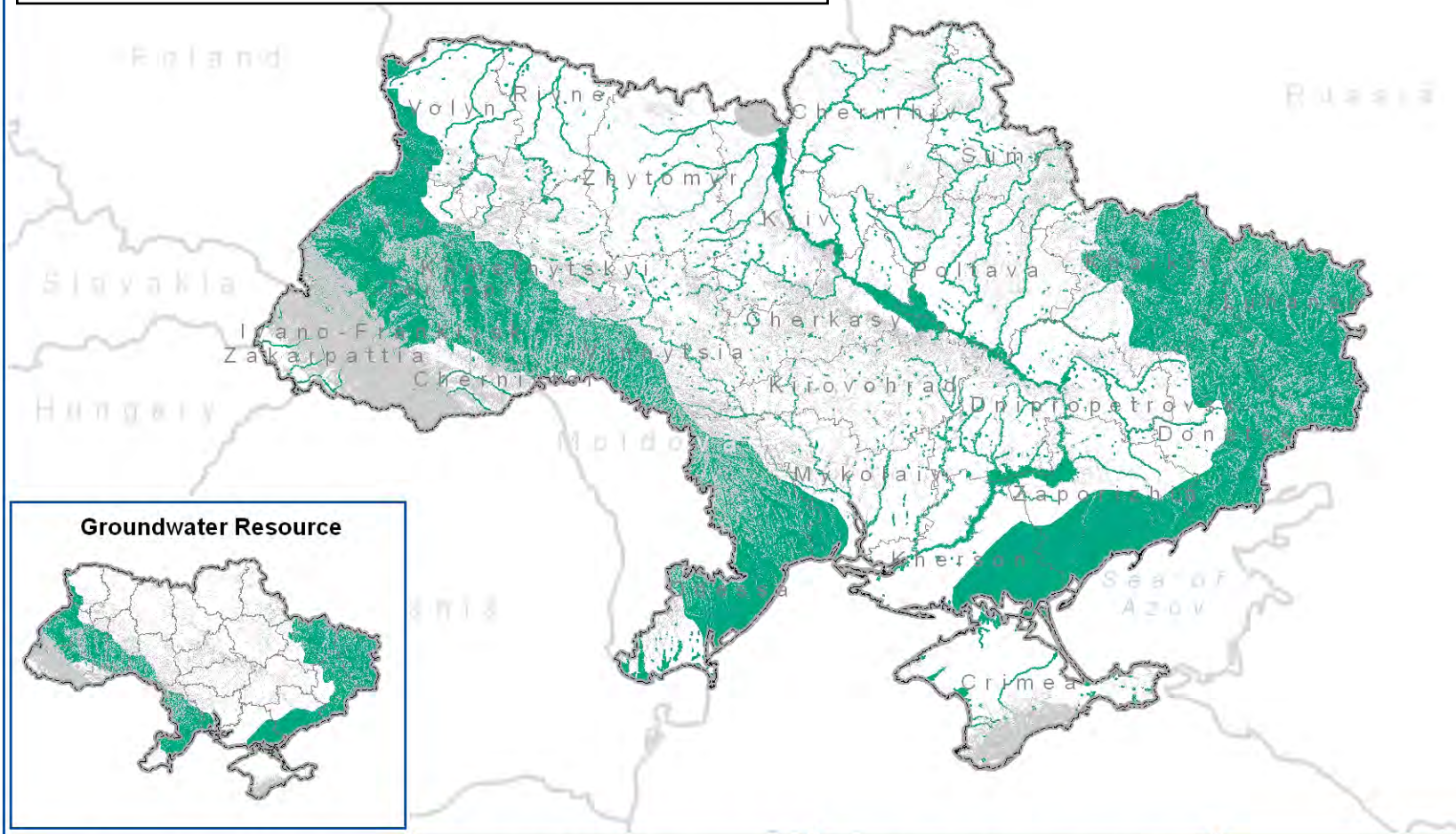
Data Sources: National Atlas of Ukraine; DeLorme; ArcWorld Supplement



0 50 100  
Kilometers  
1 cm = 80 km



**Figure SW3 Spatial constraints for Surface water and Groundwater under the solar photovoltaic renewable energy scenario**



**Surface and  
Groundwater  
Sensitivity to  
Solar  
Development**

- Legend**
- Technical Exclusions
  - Low Sensitivity
  - Medium Sensitivity
  - High Sensitivity

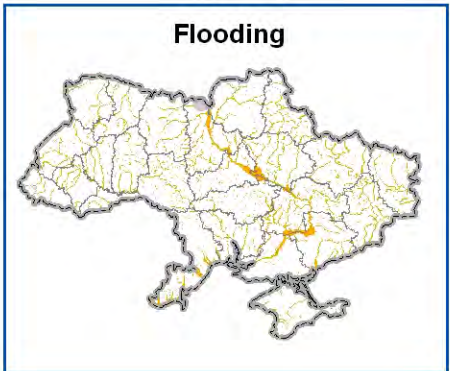
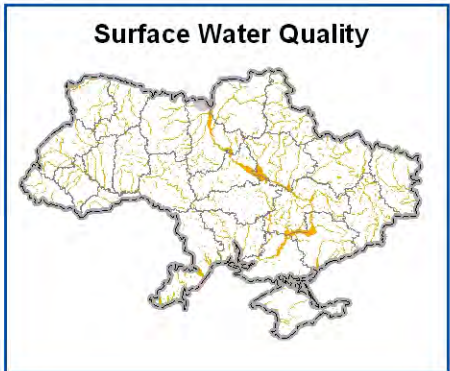
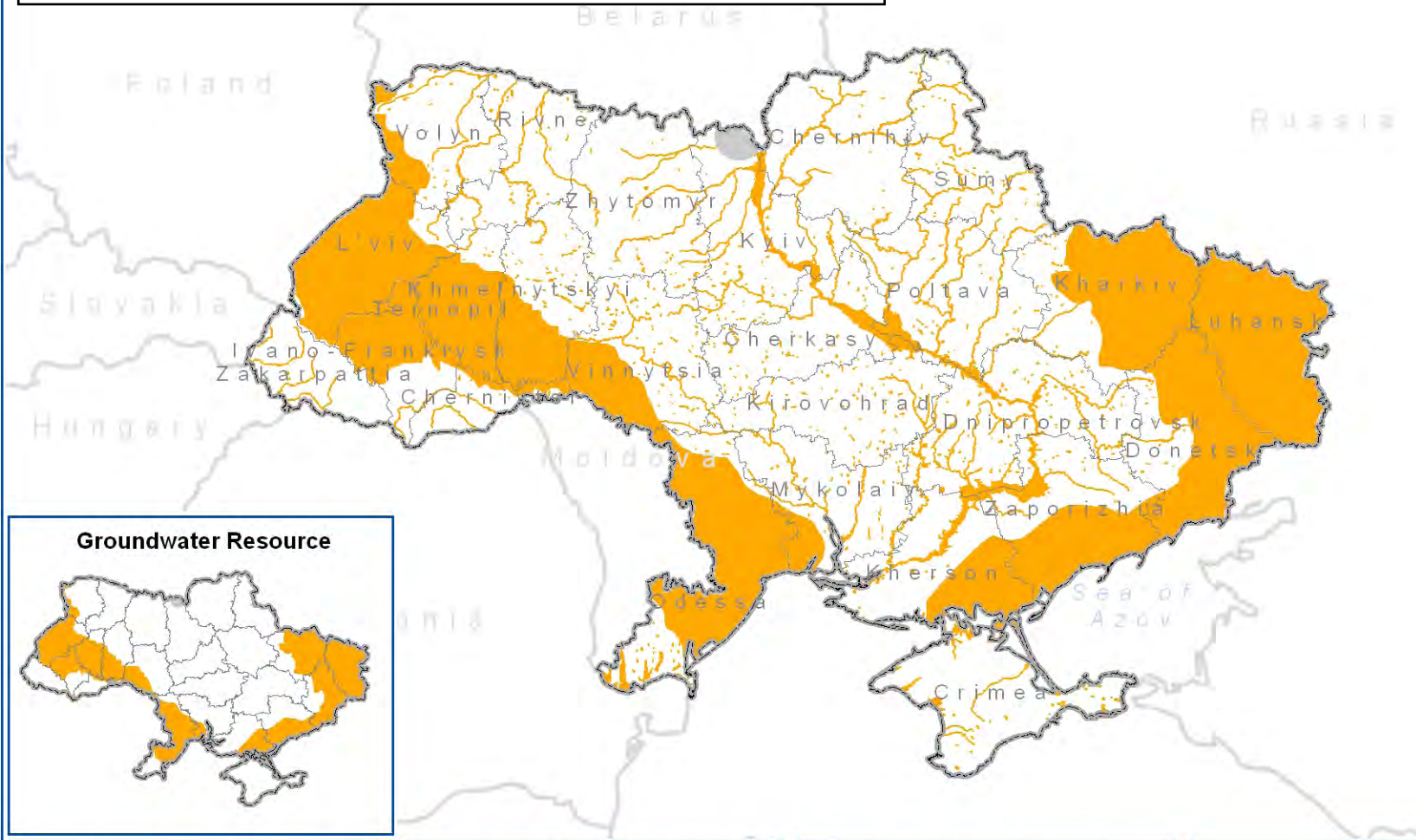
Data Sources: National Atlas of Ukraine; DeLorme; ArcWorld Supplement



0 50 100  
Kilometers  
1 cm = 80 km



**Figure SW4 Spatial constraints for Surface water and Groundwater under the biomass renewable energy scenario using agricultural residues**



**Surface and Groundwater Sensitivity to Agricultural Residues Biomass Development**

- Legend**
- Technical Exclusion
  - Sensitivity**
    - Low
    - Medium
    - High

Data Sources: National Atlas of Ukraine; DeLorme; ArcWorld Supplement

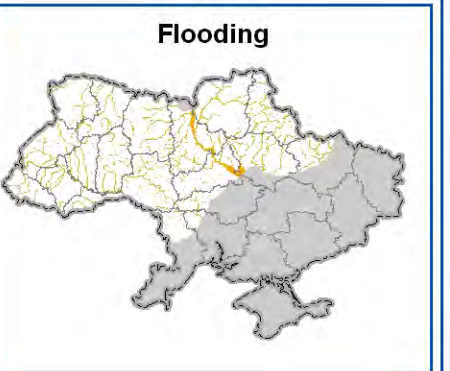
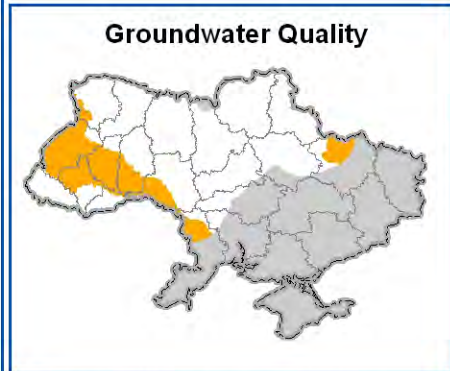


0 50 100  
Kilometers  
1 cm = 80 km



WaterSensitivity\_Crosscutting\_Inputs | J. Clewley | 20/02/2011

**Figure SW5 Spatial constraints for Surface water and Groundwater under the biomass renewable energy scenario using wood residues**



**Surface and  
Groundwater  
Sensitivity to  
Wood Residues  
Biomass  
Development**

- Legend**
- Technical Exclusion
  - Sensitivity**
    - Low
    - Medium
    - High

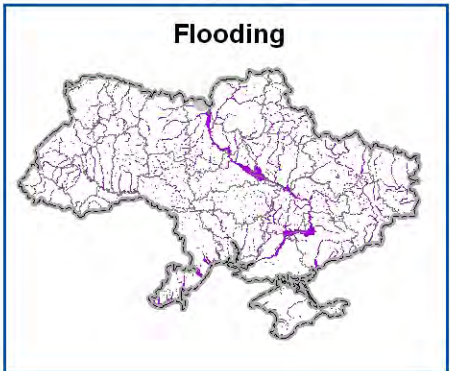
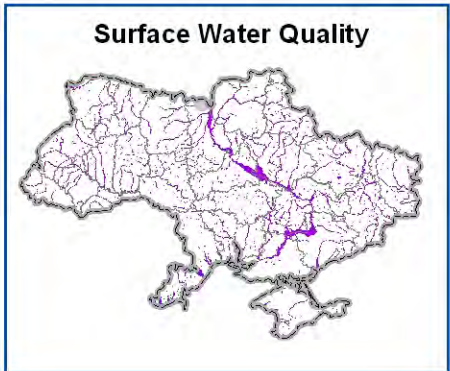
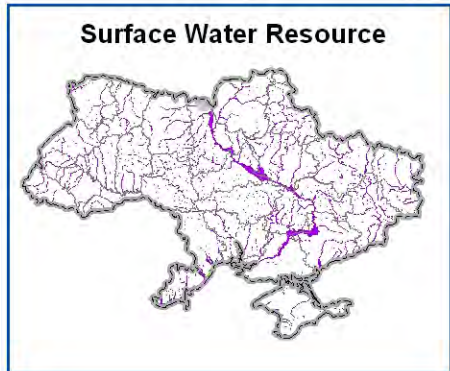
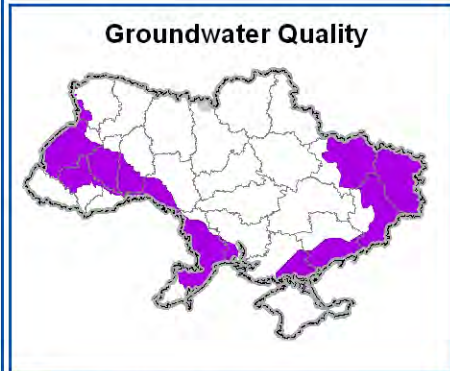
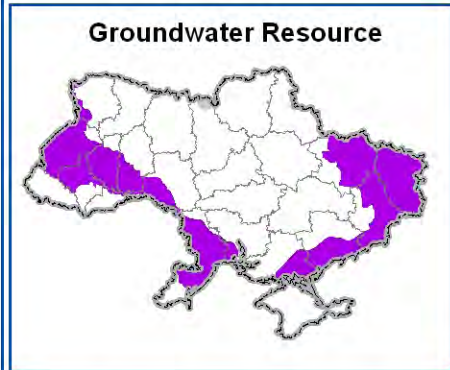
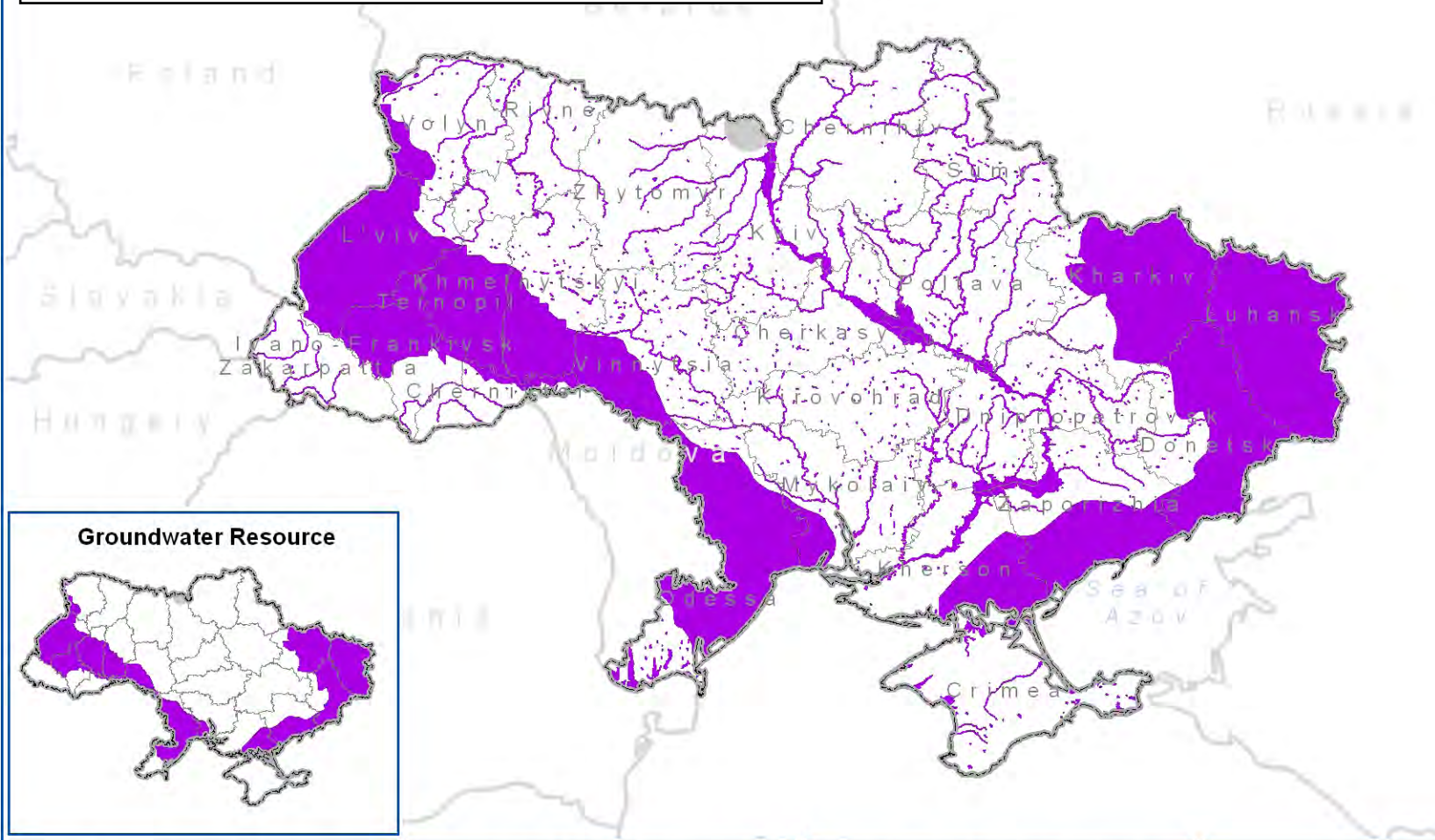
Data Sources: National Atlas of Ukraine; DeLorme; ArcWorld Supplement



0 50 100  
Kilometers  
1 cm = 80 km



**Figure SW6 Spatial constraints for Surface water and Groundwater under the biogas renewable energy scenario using animal manure**



**Surface and Groundwater Sensitivity to Animal Manure Biogas Development**

- Legend**
- Technical Exclusion
  - Sensitivity**
  - Low
  - Medium
  - High

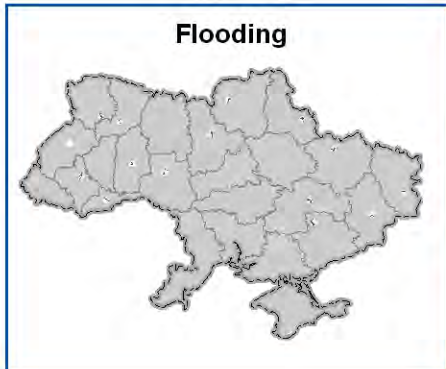
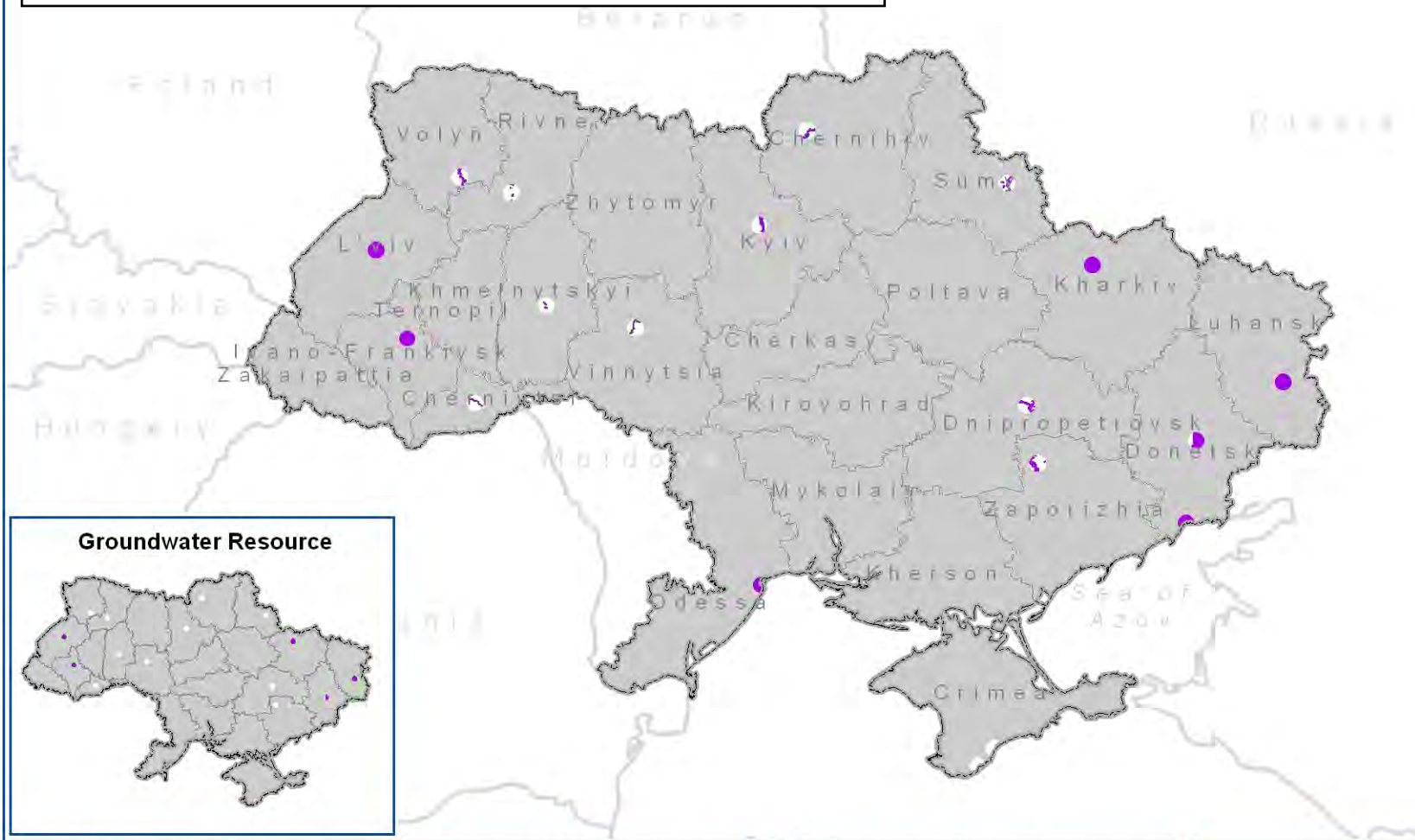
Data Sources: National Atlas of Ukraine; DeLorme; ArcWorld Supplement



0 50 100  
Kilometers  
1 cm = 80 km



**Figure SW7 Spatial constraints for Surface water and Groundwater under the biogas renewable energy scenario using municipal landfill gas**



**Surface and Groundwater Sensitivity to Landfill Gas Biogas Development**

- Legend**
- Technical Exclusion
  - Sensitivity
    - Low
    - Medium
    - High

Data Sources: National Atlas of Ukraine; DeLorme; ArcWorld Supplement

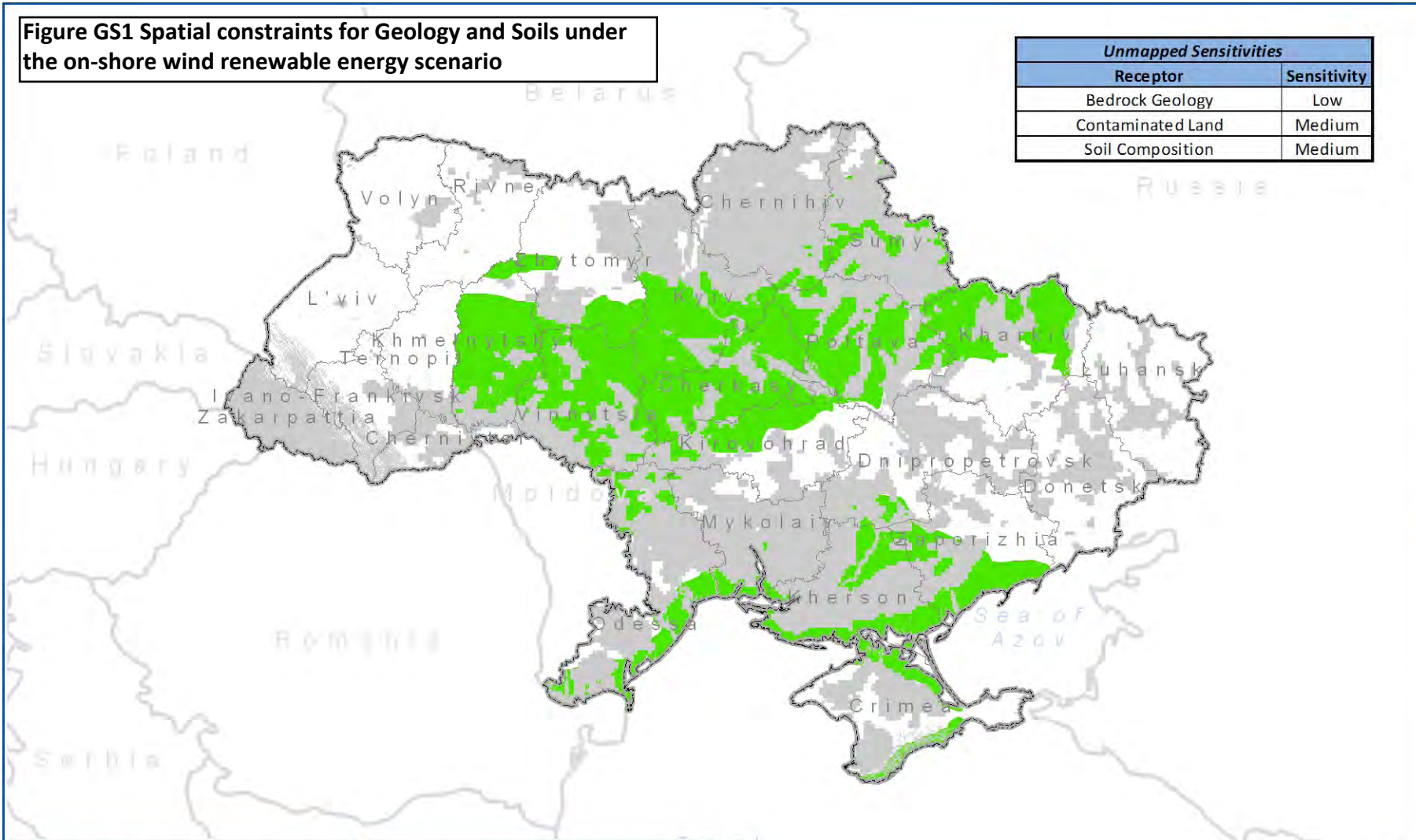


0 50 100  
Kilometers

1 cm = 80 km



**Figure GS1 Spatial constraints for Geology and Soils under the on-shore wind renewable energy scenario**



Unmapped Sensitivities	
Receptor	Sensitivity
Bedrock Geology	Low
Contaminated Land	Medium
Soil Composition	Medium

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**Soils and Geology Sensitivity to Wind Development**

- Legend**
- Technical Exclusions
  - Sensitivity**
    - Low
    - Medium
    - High

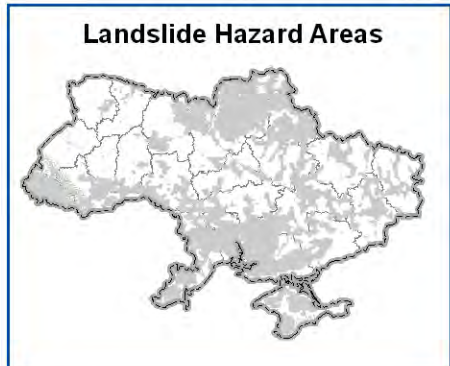
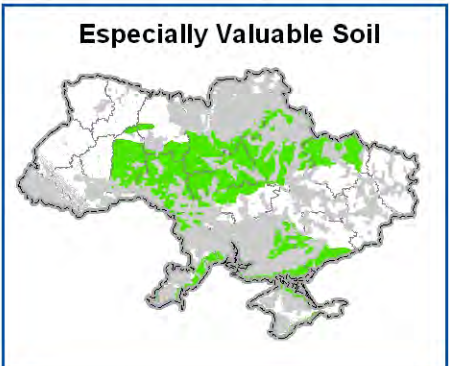
Data Sources: National Atlas of Ukraine; SRTM; DeLorme; ArcWorld Supplement;



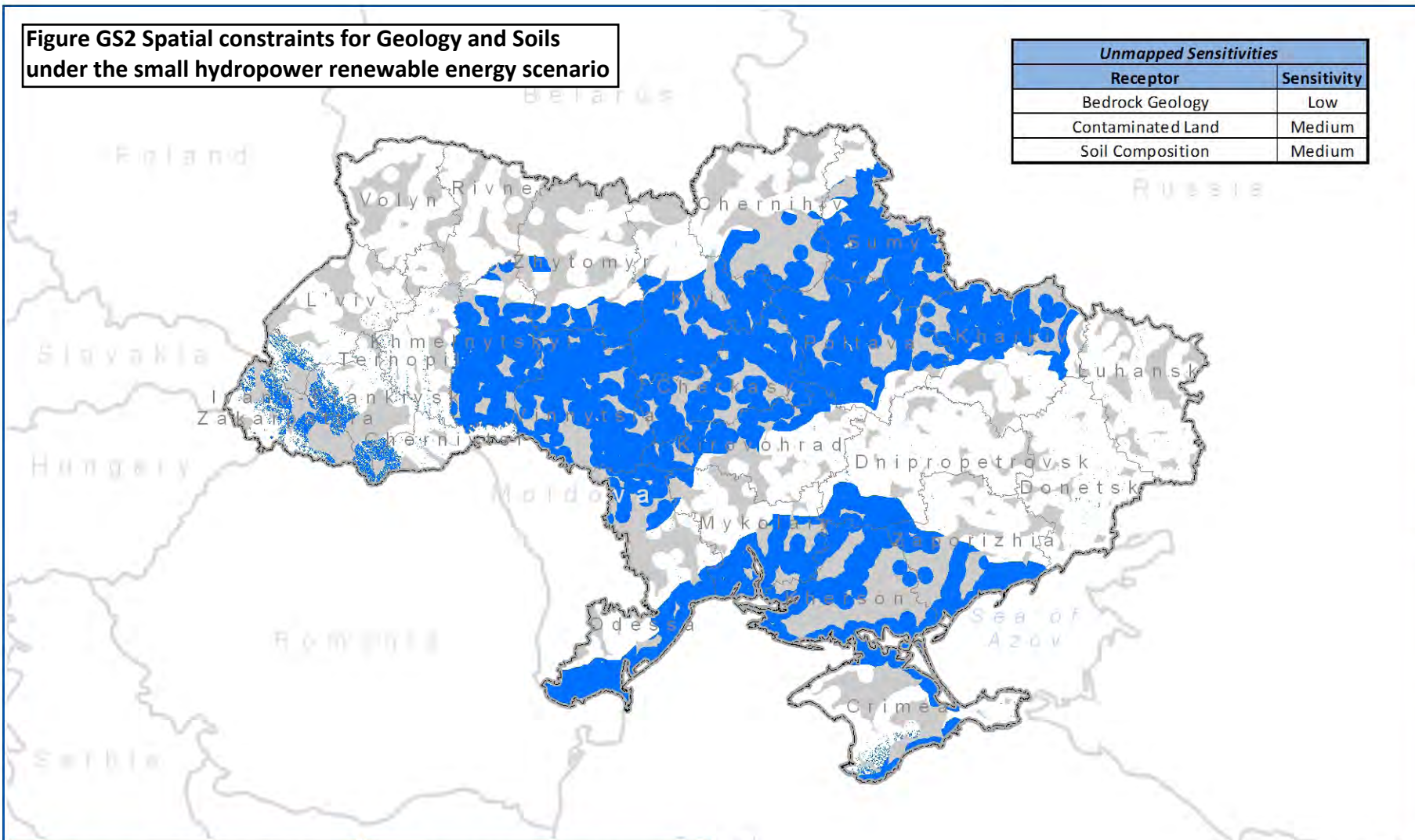
0 50 100

Kilometers

1 cm = 80 km



**Figure GS2 Spatial constraints for Geology and Soils under the small hydropower renewable energy scenario**



Unmapped Sensitivities	
Receptor	Sensitivity
Bedrock Geology	Low
Contaminated Land	Medium
Soil Composition	Medium

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**Soils and Geology Sensitivity to Small Hydro Development**

**Legend**

- Technical Exclusions

**Sensitivity**

- None
- Low
- Medium
- High

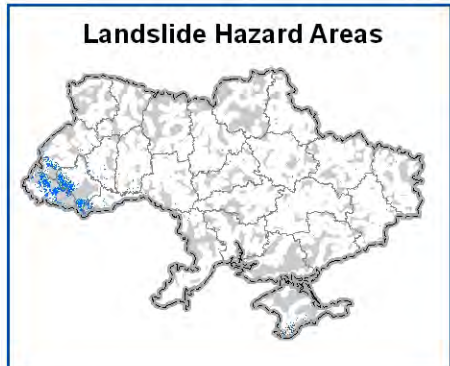
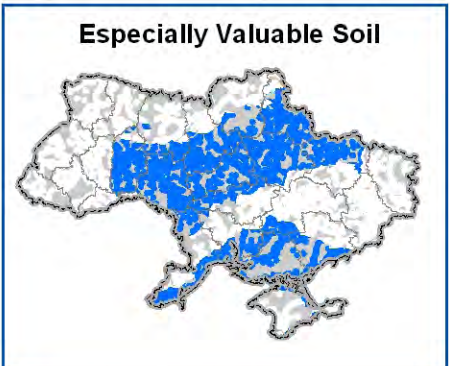
Data Sources: National Atlas of Ukraine; SRTM; DeLorme; ArcWorld Supplement;



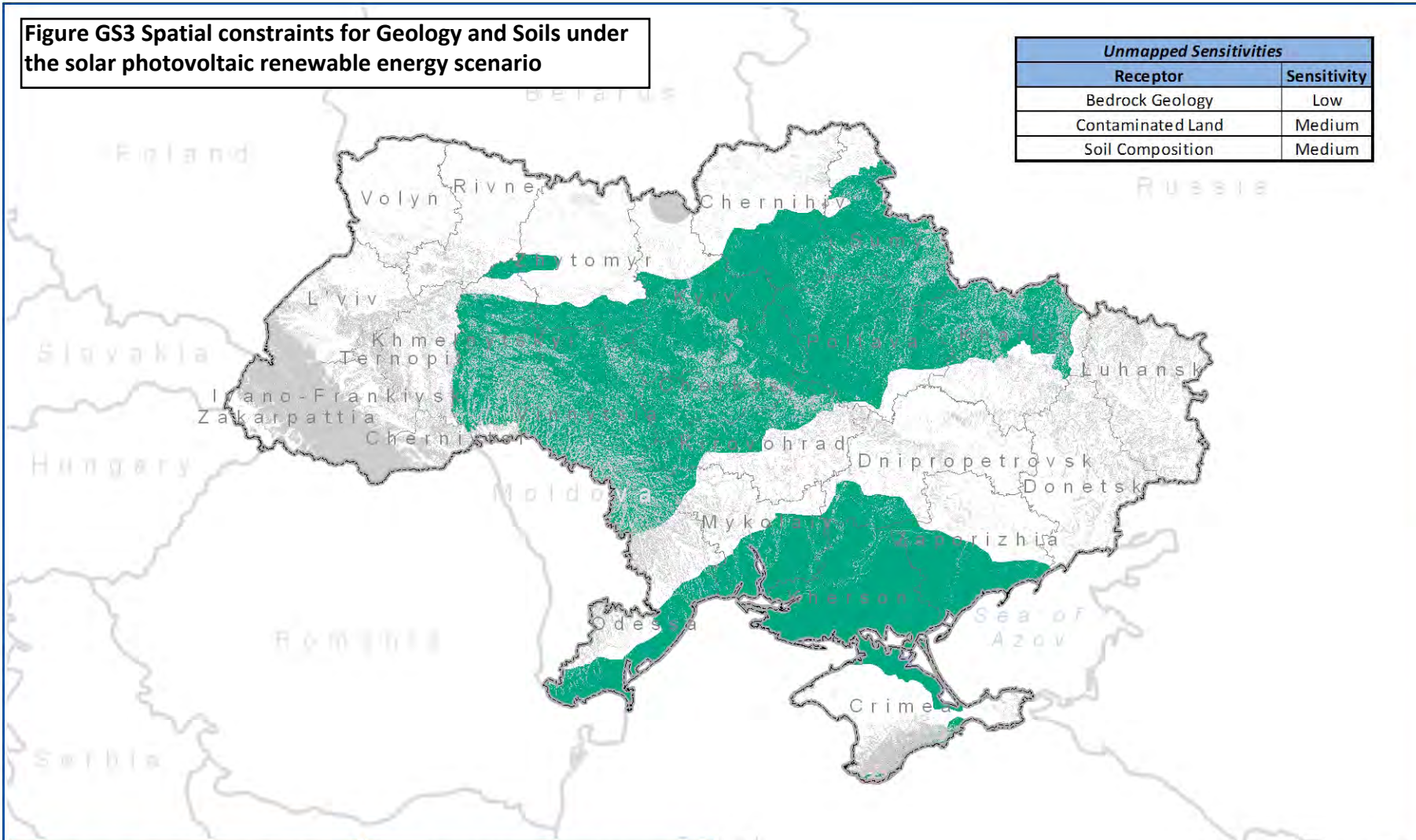
0 50 100

Kilometers

1 cm = 80 km



**Figure GS3 Spatial constraints for Geology and Soils under the solar photovoltaic renewable energy scenario**



Unmapped Sensitivities	
Receptor	Sensitivity
Bedrock Geology	Low
Contaminated Land	Medium
Soil Composition	Medium

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**Soils and Geology Sensitivity to Solar Development**

- Legend**
- Technical Exclusions
  - Sensitivity**
  - Low
  - Medium
  - High

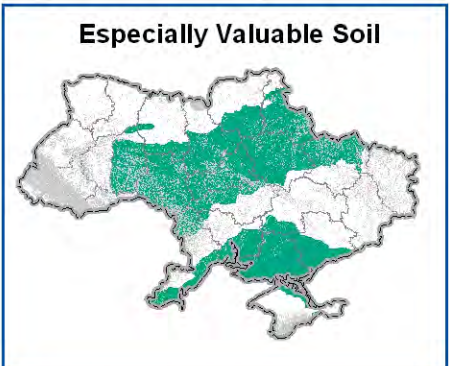
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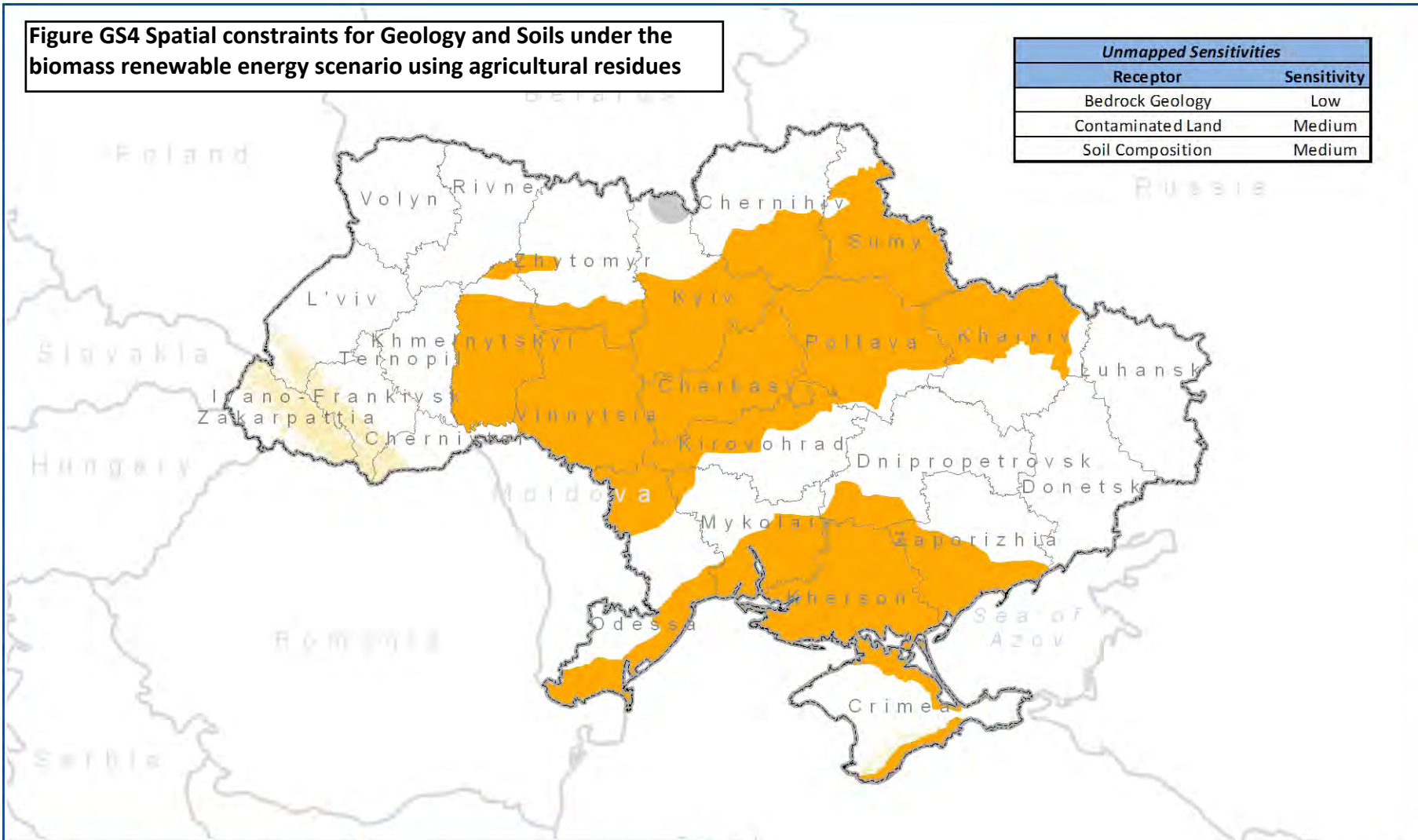
0 50 100

Kilometers

1 cm = 80 km



**Figure GS4 Spatial constraints for Geology and Soils under the biomass renewable energy scenario using agricultural residues**



**Ukraine Sustainable Energy Lending Facility Strategic Environmental Review**

**Soils and Geology Sensitivity to Agricultural Residues Biomass Development**

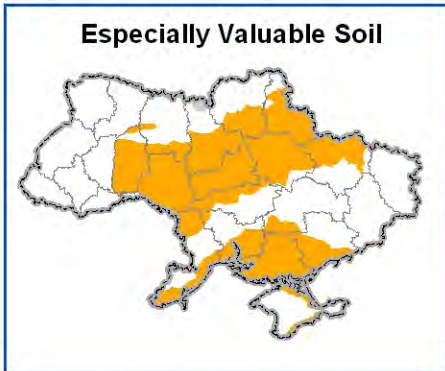
- Legend**
- Technical Exclusion
  - Sensitivity**
  - Low
  - Medium
  - High

Data Sources: National Atlas of Ukraine; SRTM; DeLorme; ArcWorld Supplement;

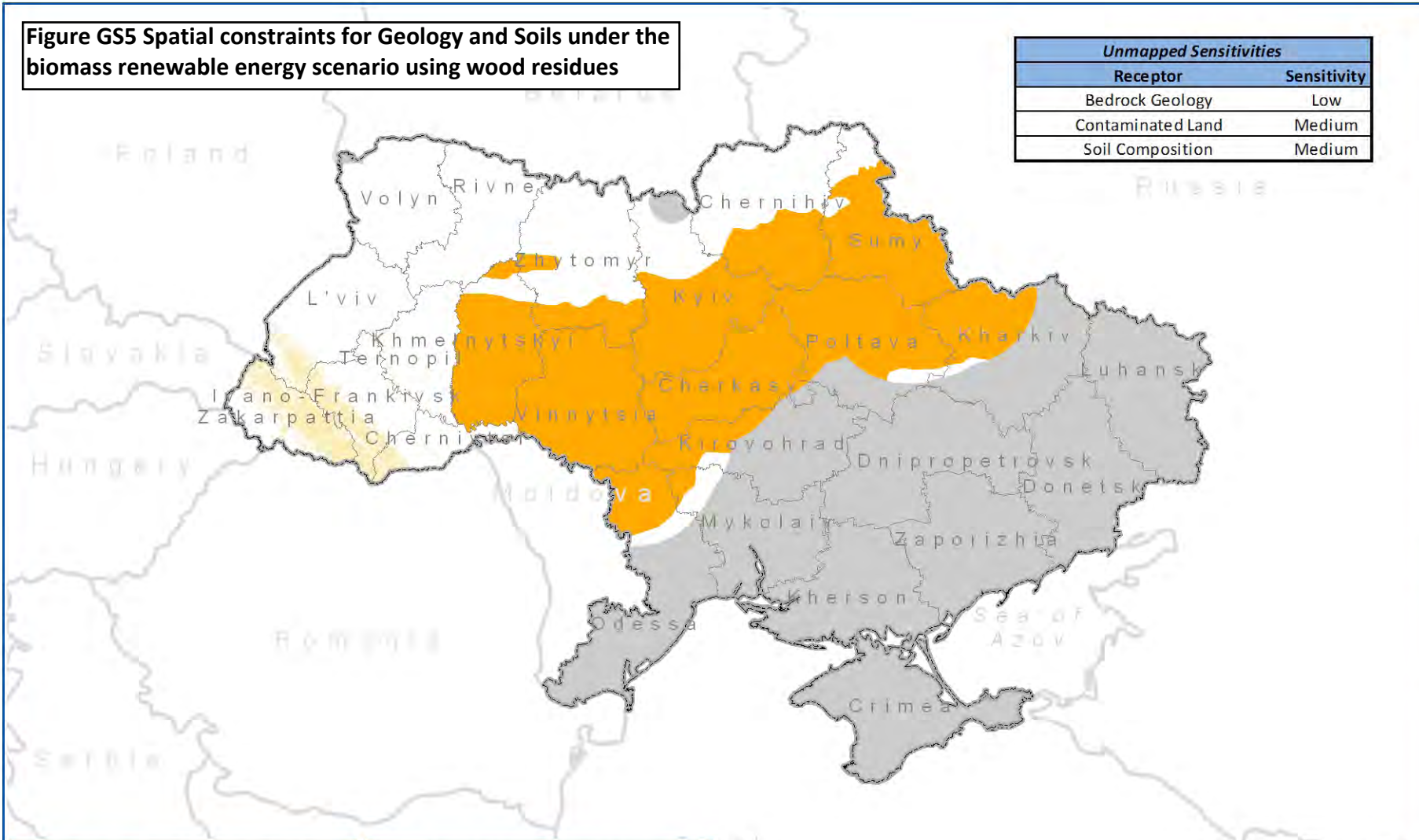


0 50 100  
Kilometers

1 cm = 80 km



**Figure GS5 Spatial constraints for Geology and Soils under the biomass renewable energy scenario using wood residues**



Unmapped Sensitivities	
Receptor	Sensitivity
Bedrock Geology	Low
Contaminated Land	Medium
Soil Composition	Medium

**Ukraine Sustainable Energy Lending Facility Strategic Environmental Review**

**Soils and Geology Sensitivity to Wood Residues Biomass Development**

- Legend**
- Technical Exclusion
  - Sensitivity**
  - Low
  - Medium
  - High

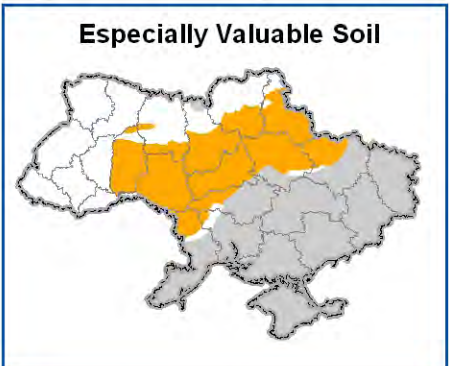
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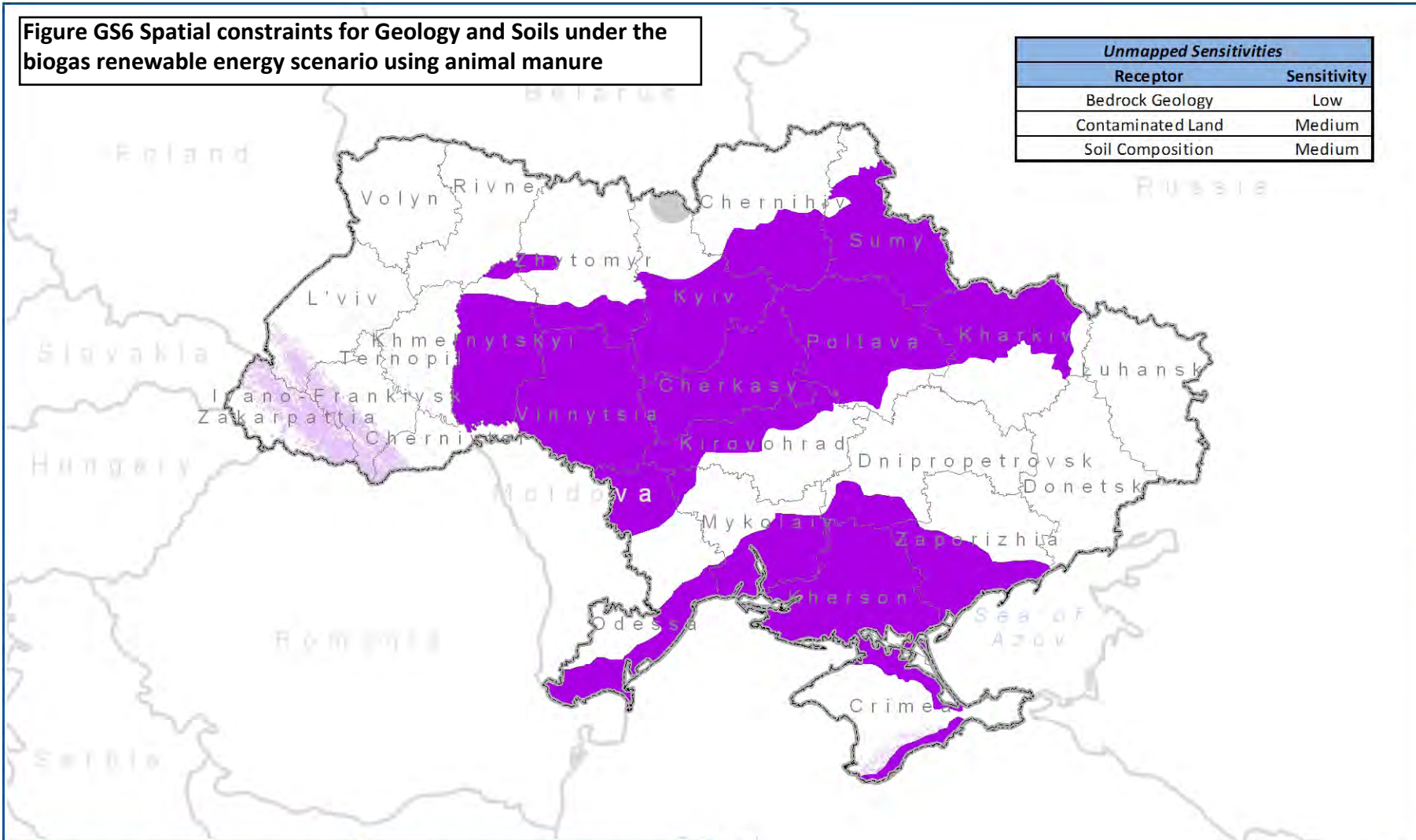
0 50 100

Kilometers

1 cm = 80 km



**Figure GS6 Spatial constraints for Geology and Soils under the biogas renewable energy scenario using animal manure**



Unmapped Sensitivities	
Receptor	Sensitivity
Bedrock Geology	Low
Contaminated Land	Medium
Soil Composition	Medium

**Ukraine Sustainable Energy Lending Facility Strategic Environmental Review**

**Soils and Geology Sensitivity to Animal Manure Biogas Development**

- Legend**
- Technical Exclusion
  - Sensitivity**
  - Low
  - Medium
  - High

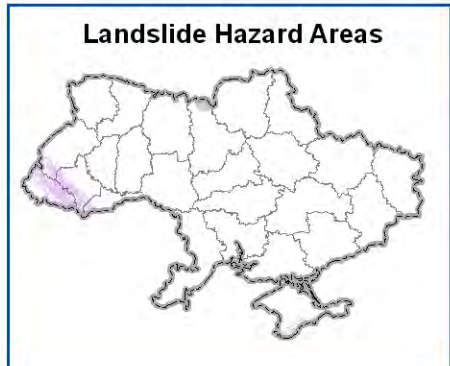
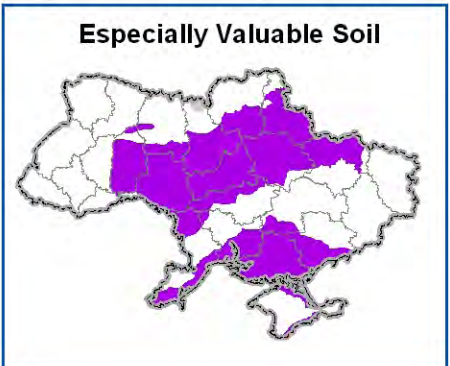
Data Sources: National Atlas of Ukraine; SRTM; DeLorme; ArcWorld Supplement;



0 50 100

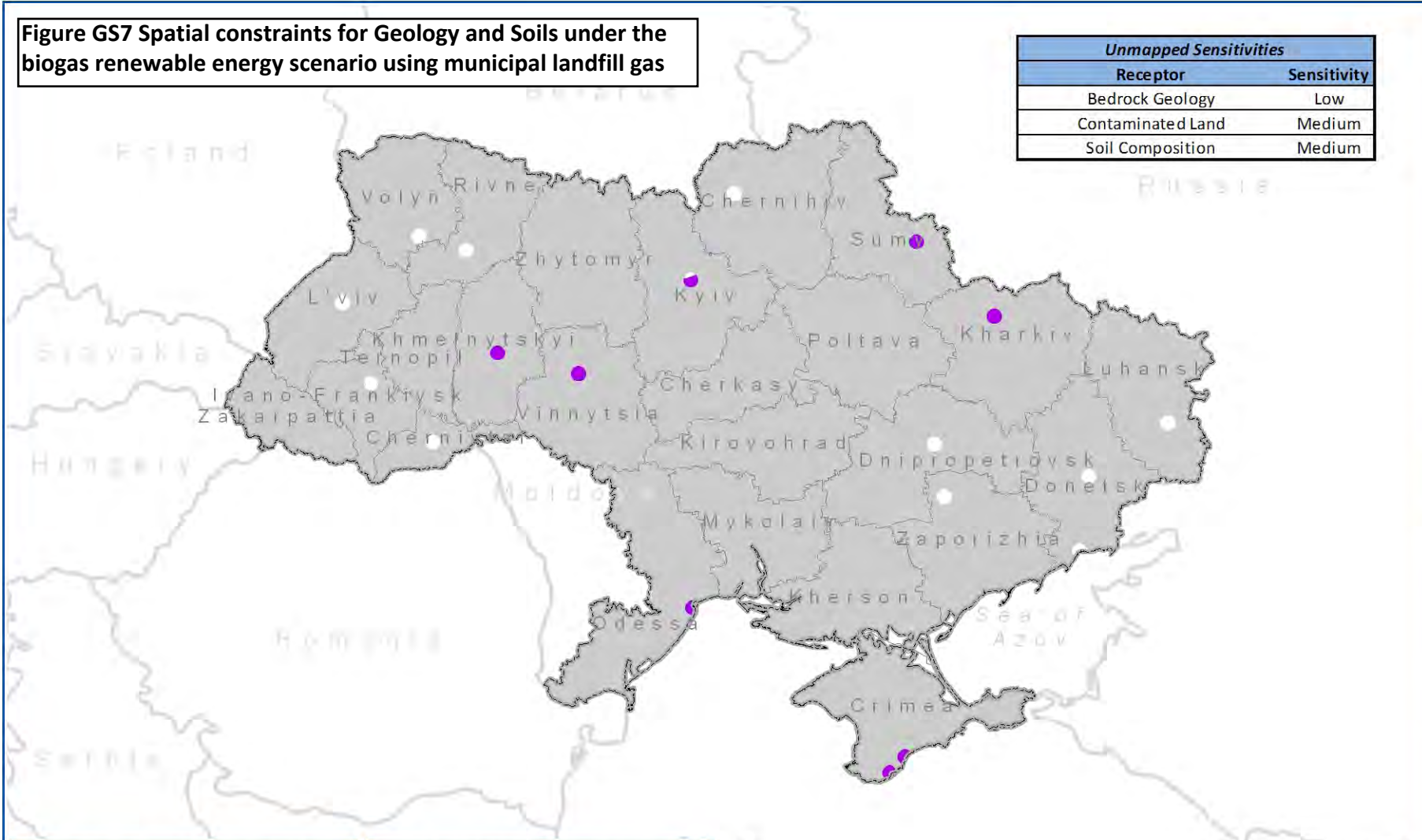
Kilometers

1 cm = 80 km





**Figure GS7 Spatial constraints for Geology and Soils under the biogas renewable energy scenario using municipal landfill gas**



Unmapped Sensitivities	
Receptor	Sensitivity
Bedrock Geology	Low
Contaminated Land	Medium
Soil Composition	Medium

**Ukraine Sustainable Energy Lending Facility Strategic Environmental Review**

**Soils and Geology Sensitivity to Landfill Gas Biogas Development**

**Legend**

**Sensitivity**

- Low
- Medium
- High
- Technical Exclusion

Data Sources: National Atlas of Ukraine; SRTM; DeLorme; ArcWorld Supplement;



0 50 100

Kilometers

1 cm = 80 km

