APEC 8601 Final Project

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Component 1:

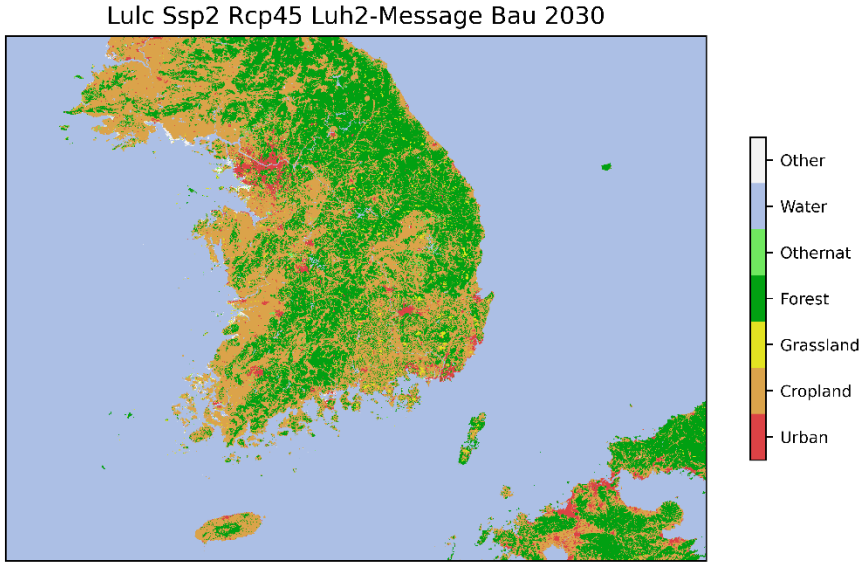
Part a: I used SEALS to generate LULC maps for South Korea for 2030, 2035, and 2040 under two different Shared Socioeconomic Pathways (SSP2 and SSP3)

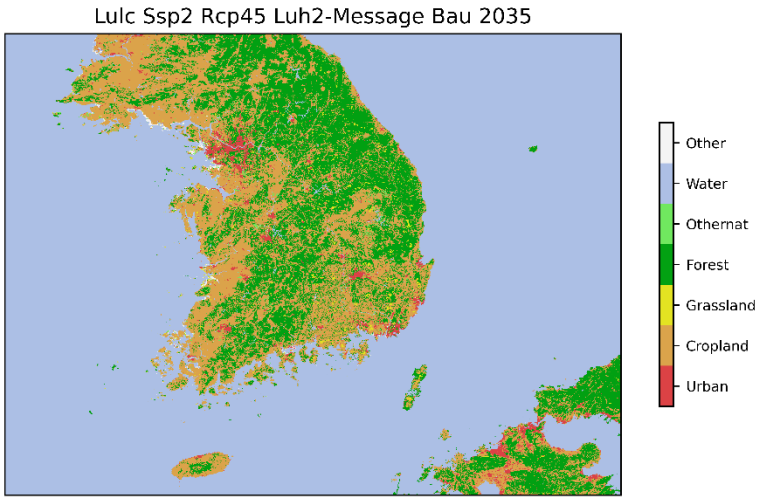
Part b: I have plotted these maps using QGIS in files named KOREAN SSP 2 AND SSP 3

Part c: To address specific land use change policies, I've added a policy layer that prohibits farmland change. This was done by setting the calibration values to zero in the' cropland_constraint ' of the multiplicative calibration type, effectively preventing changes in farmland areas across the scenarios.

Part d:

For SSP2

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Other
Water
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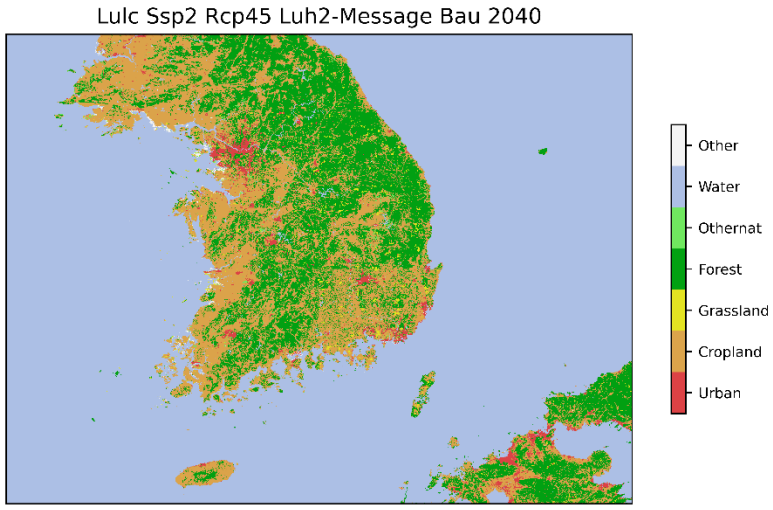
Cropland
Urban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For SSP 3

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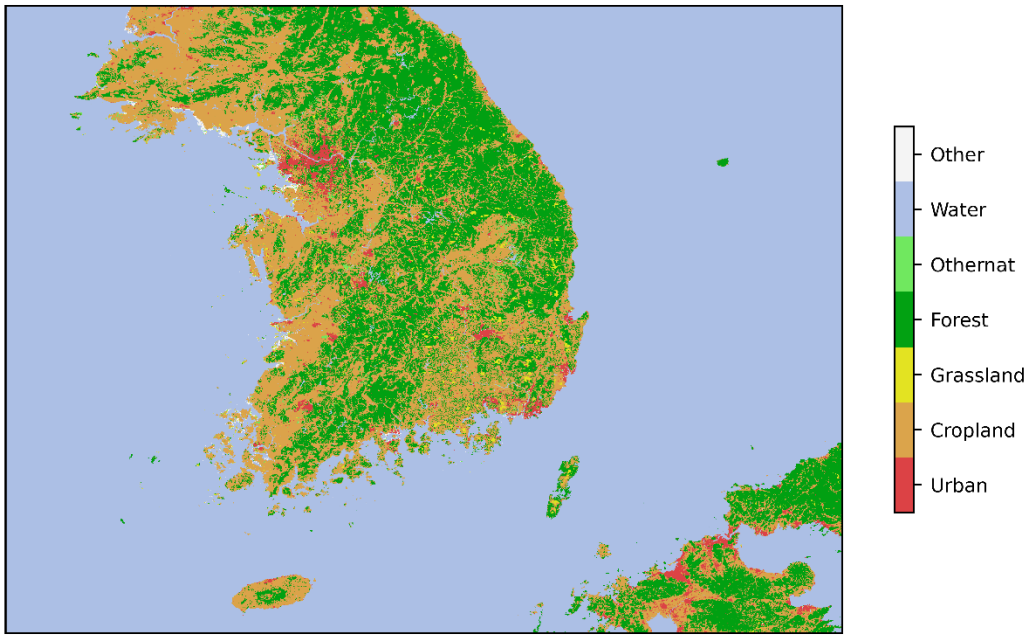

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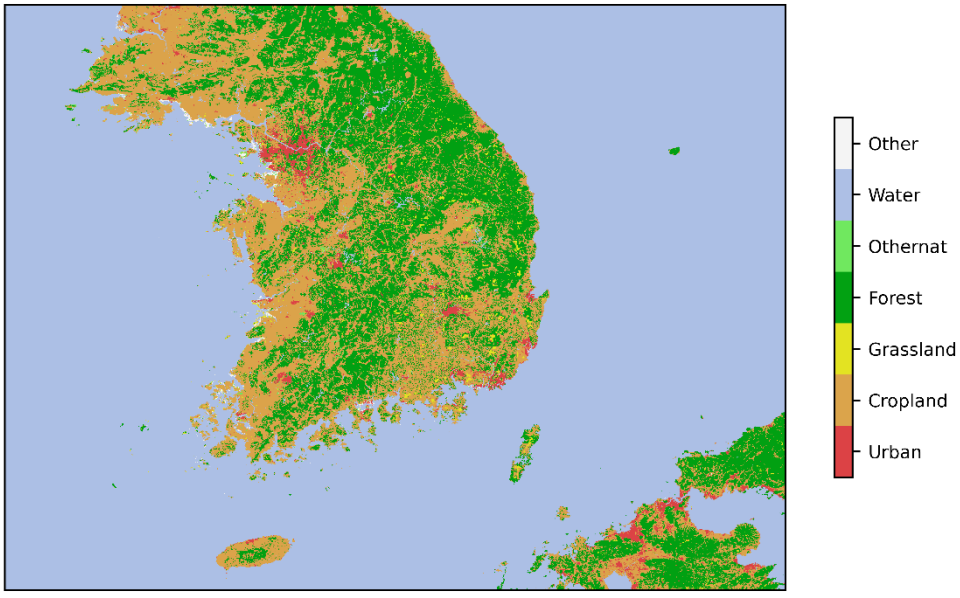
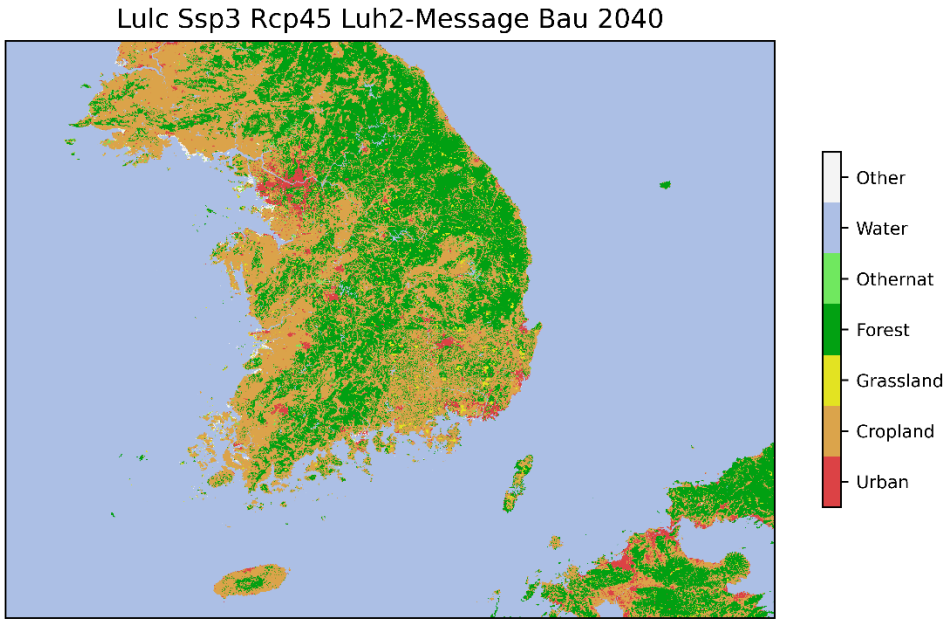
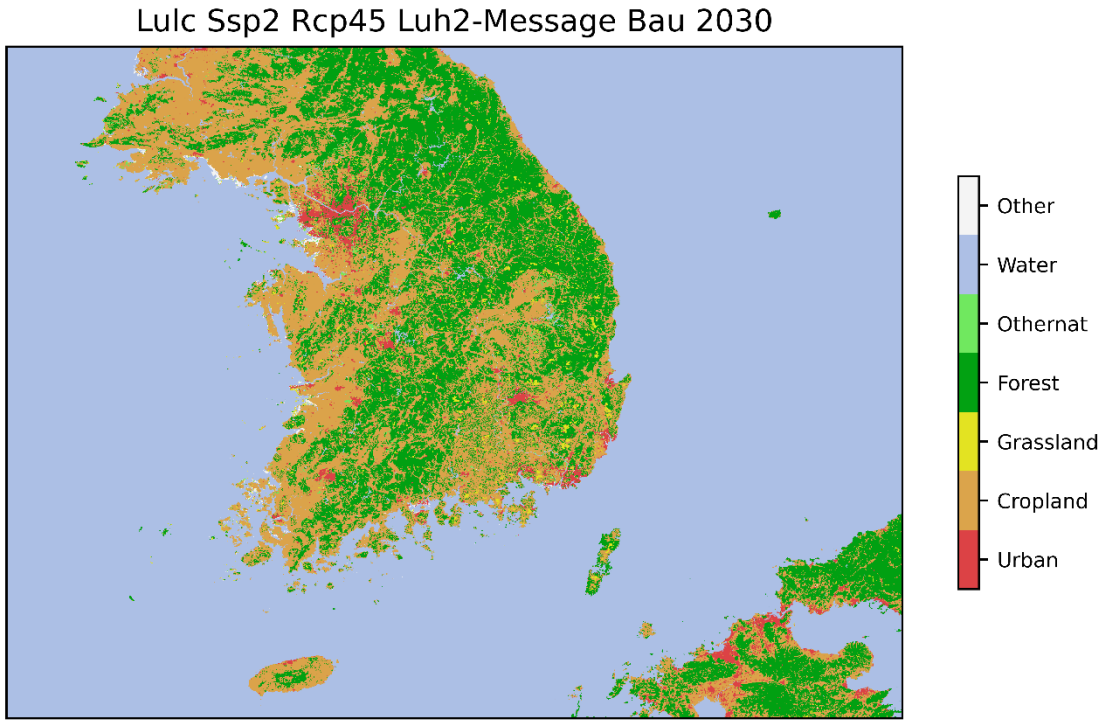




For SSP 2 under Policy



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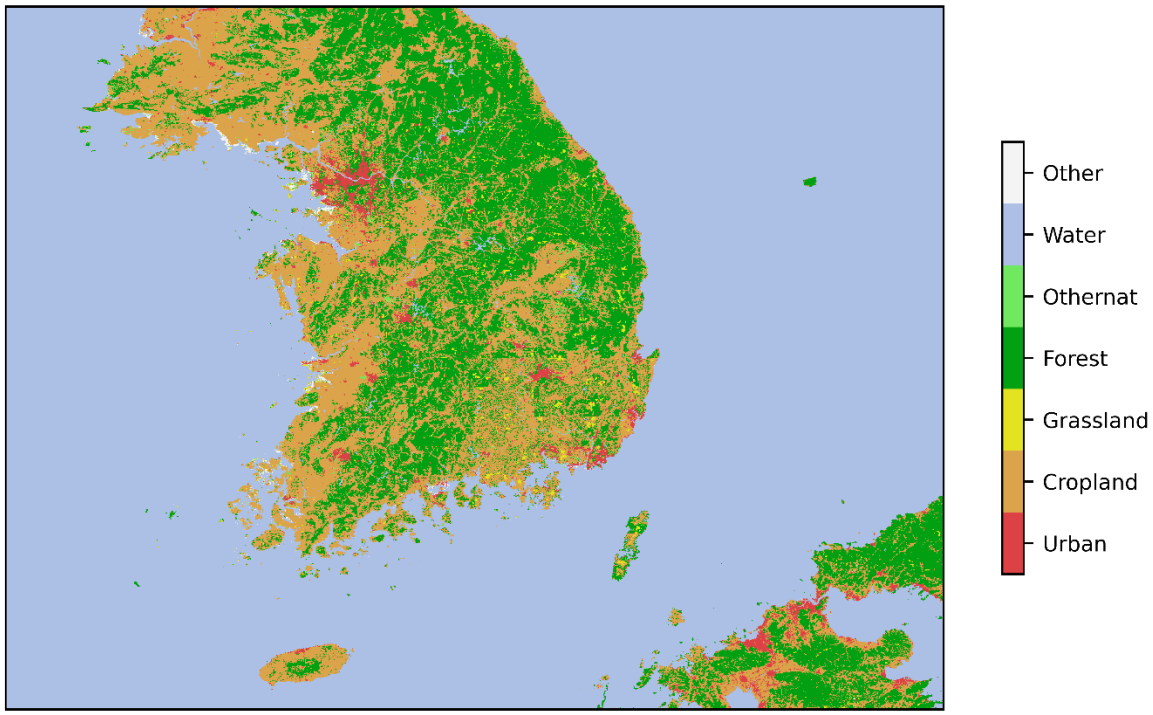

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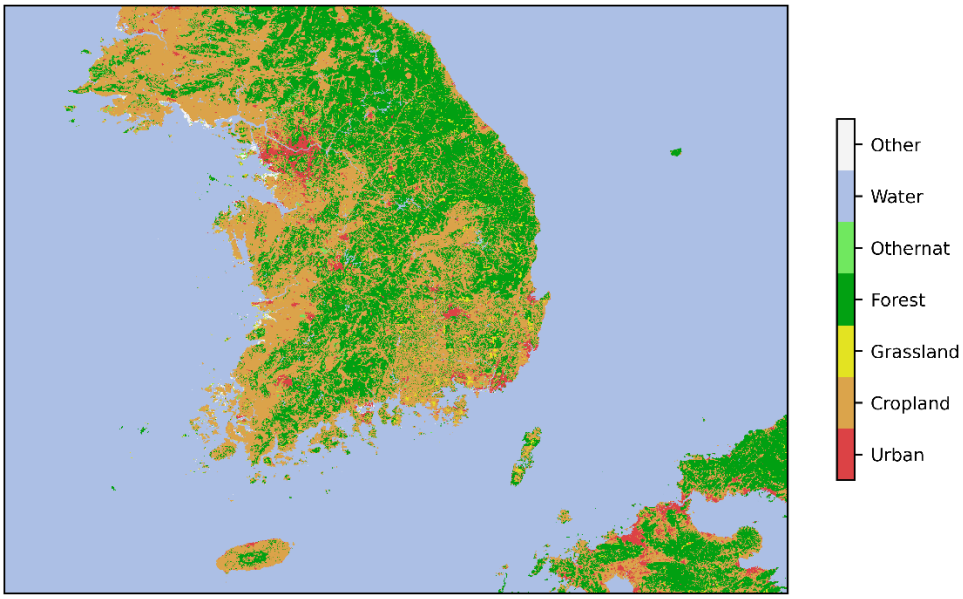

General Observations

Forest (Green): Represents forested areas, likely showing less change relative to other classes since these areas are often protected or less easily converted.

Grassland (Yellow): Could indicate either natural grasslands or those used for agricultural purposes like grazing. Changes here might reflect shifts in agricultural practices or reforestation/afforestation efforts.

Cropland (Orange): Areas used for crop production. Changes reflect shifts in agricultural policy, technology, or shifts due to urban expansion.

Urban (Red): Urbanized areas, likely to expand in most scenarios, reflecting population growth and economic development.

Water and Others (Blue and Gray): Generally stable unless significant infrastructural changes occur, such as dam construction.

Specific Trends Across the Scenarios

SSP2 Pathway: 2030 to 2040

2030: Initial distribution shows a balance among forest, grassland, and cropland, with urban areas concentrated around specific regions.

2035: Increased urbanization can be seen encroaching on areas previously classified as cropland or grassland, reflecting economic growth and population increase.

2040: The trend continues with further urban expansion. There might be an increase in cropland as well, possibly due to agricultural intensification or conversion of other land types to meet food demands.

SSP3 Pathway: 2030 to 2040

2030: Similar start as SSP2, but with potentially more extensive forest and grassland areas, indicating possible differences in environmental or agricultural policies.

2035: Urban expansion might be slower compared to SSP2, suggesting more stringent controls on urban sprawl or better integration of urban planning with sustainable practices.

2040: Urban areas continue to grow, but there is a noticeable effort to preserve more natural land types, possibly through policies encouraging sustainable land management or technological advances in agriculture that reduce the need for new croplands.

Policy Implications: Different policies under SSP2 and SSP3 lead to visibly different landscape configurations, which could have implications for biodiversity, climate change mitigation strategies, and food security.

Component 2

Carbon Storage Results Analysis

SSP2 Results (2030, 2035, 2040)

Figures 1-1 to 1-3 illustrate carbon storage levels for the SSP2 scenarios across three consecutive years: 2030, 2035, and 2040. As observed, there is a slight but steady decrease in carbon storage over time. This trend could be reflective of typical environmental degradation or shifts in land use that mildly impact carbon sequestration capabilities.

Fig 1-1. Carbon storage for SSP2 2030

Fig 1-2. Carbon storage for SSP2 2035

Fig 1-3. Carbon storage for SSP2 2040

SSP3 Results (2030, 2035, 2040)

Moving on to Figures 1-4 to 1-6, the carbon storage data for SSP3 across the same years show a pattern like that of SSP2. The lack of variance between SSP2 and SSP3 under normal conditions suggests that potential conflicts and lower cooperation modeled under SSP3 do not significantly alter basic ecological functions like carbon storage when compared to a more moderate SSP2 scenario without policy changes.

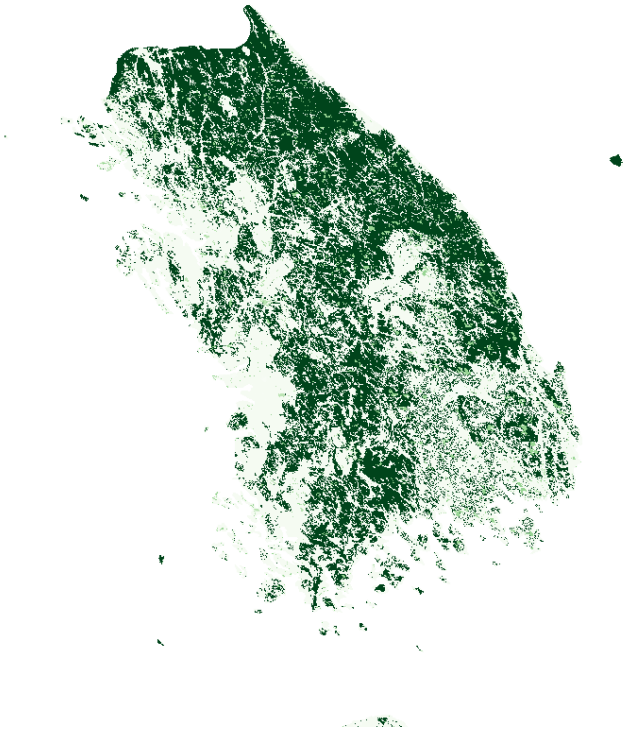

Fig 1-4. Carbon storage for SSP3 2030

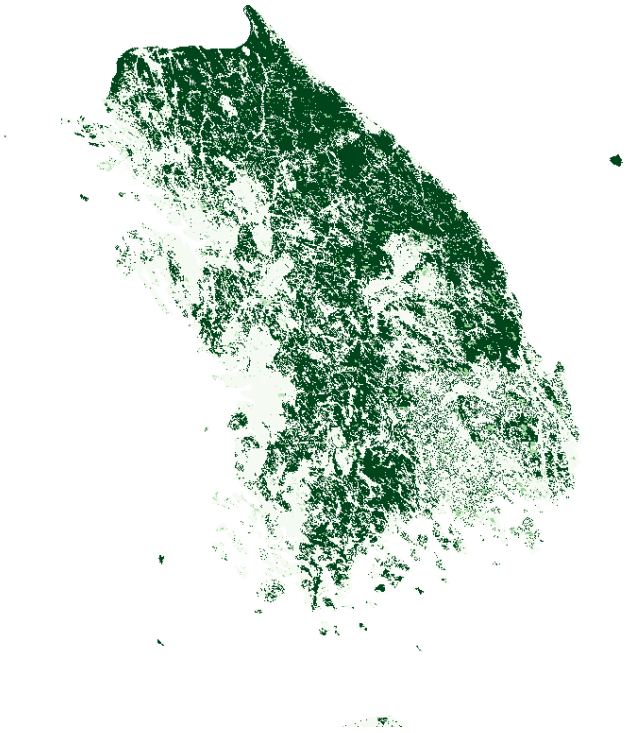

Fig 1-5. Carbon storage for SSP3 2035

Fig 1-6. Carbon storage for SSP3 2040

SSP2 Results Under Policy (2030, 2035, 2040)

Figures 1-7 to 1-9 show carbon storage for SSP2 with a no agricultural land change policy. The introduction of this policy leads to a more pronounced decrease in carbon storage. This could be interpreted as a consequence of restricting land use changes that might otherwise contribute to higher carbon sequestration, such as afforestation or improved agricultural practices.

Fig 1-7. Carbon storage for SSP2 2030 under policy

Fig 1-8. Carbon storage for SSP2 2035 under policy

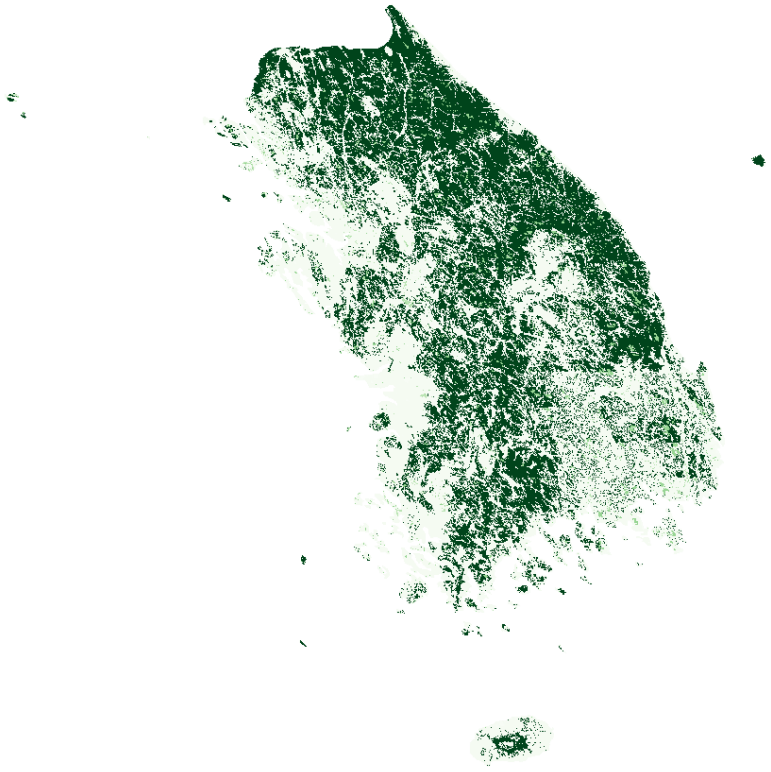

Fig 1-9.Carbon storage for SSP2 2040 under policy

Overall Observations

Both SSP2 and SSP3 scenarios without specific policies exhibit a gentle decline in carbon storage, indicative of ongoing but mild impacts from land use changes or environmental degradation. The introduction of a no agricultural land change policy under SSP2 accelerates this decline, highlighting potential unintended consequences of such policies. This could suggest a need for reevaluating these policies to ensure they do not counterproductively affect carbon storage goals.

Regional variations are notable, with the northeast region displaying stability and higher carbon storage, hinting at regional differences in ecological resilience or management effectiveness. Conversely, the southeast region shows a vulnerability to decreasing carbon storage under all scenarios, with this decrease more accentuated under SSP2 with the no agricultural land change policy. These underscores potential limitations of such policies in effectively managing carbon storage and suggests a need for tailored regional approaches to land and environmental management.

Water yield result

Fig 2-1. Water yield for SSP2 2030

Fig 2-2. Water yield for SSP2 2035

Fig 2-3. Water yield for SSP2 2040

Fig 2-4. Water yield for SSP3 2030

Fig 2-5. Water yield for SSP3 2035

Fig 2-6. Water yield for SSP3 2040

Fig 2-7. Water yield for SSP2 2030 under policy

Fig 2-8. Water yield for SSP2 2035 under policy

Fig 2-9. Water yield for SSP2 2040 under policy

There are some summary：

1. Overall Change Between Different SSP2 Years

For the SSP2 scenarios across different years (2030, 2035, 2040), there is a slight increase in the mean water yield values, reflecting a gradual increase over the decade. The mean values progressed from approximately 716.24 mm in 2030 to 718.45 mm in 2040. The standard deviation also increased slightly, suggesting a modest increase in the variability of water yield across the area.

2. Regional Change Between Different SSP2 Years

The data indicates minimal variation in the range of water yields (minimum and maximum values remain constant at 0.0 mm and 1780.40 mm, respectively), suggesting that while average conditions may have changed slightly, extreme values remained stable. This could imply that certain regions did not experience significant changes in water yield, while others might have seen slight increases.

3. Overall Change Between Different SSP3 Years

Similar to SSP2, the SSP3 scenarios also show a gradual increase in mean water yield values over the years, with mean values rising from approximately 716.24 mm in 2030 to 718.45 mm in 2040. This consistent increase across both SSP2 and SSP3 scenarios suggests a broader trend of increasing water yields over the decade.

4. Regional Change Between Different SSP3 Years

The maximum water yield values remained constant at 1780.40 mm across the SSP3 years, consistent with the SSP2 data. This indicates stability in the regions producing the highest water yields, with no significant increases or decreases.

5. Overall Change Between Different SSP2 Under the Policy (No Agricultural Land Change)

The introduction of policy constraints (no agricultural land change) resulted in a similar trend in mean water yield values, increasing from 717.33 mm in 2030 to 722.15 mm in 2040. The standard deviation values are quite similar to those observed in the non-policy scenarios, suggesting that the policy might not have significantly altered the variability of water yields.

6. Regional Change Between Different SSP2 Under the Policy (No Agricultural Land Change)

The range of water yields in the policy scenario shows a stable pattern, with maximum values constant at 1775.80 mm. This stability, even under policy constraints, indicates that the highest yielding regions remained unaffected by the policy changes.

Overall Summarization

Across all scenarios and policies, the data indicates a slight but steady increase in mean water yields over the decade from 2030 to 2040. The stability in minimum and maximum values suggests that while average water availability may be increasing, the regions with the highest and lowest yields are not experiencing dramatic changes. The implementation of policies restricting changes in agricultural land use does not appear to significantly affect the overall trends, indicating that other factors might be driving the observed increases in water yields. These findings suggest a robustness in water yield patterns despite varying policy and environmental scenarios.

Crop pollination

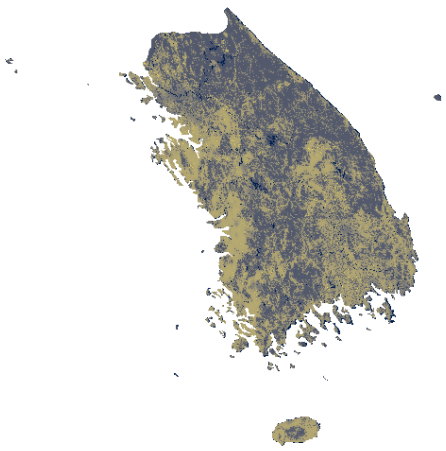

Fig 3-1 Spring crop pollination for SSP2 2030

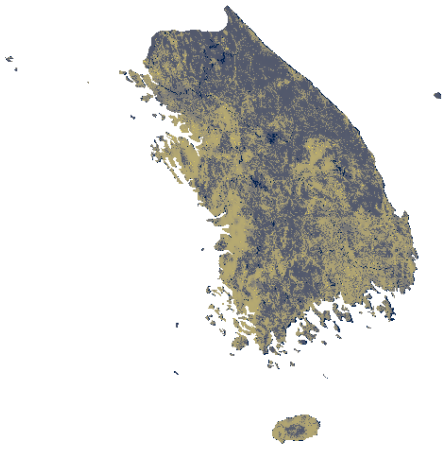

Fig 3-2 Spring crop pollination for SSP2 2035

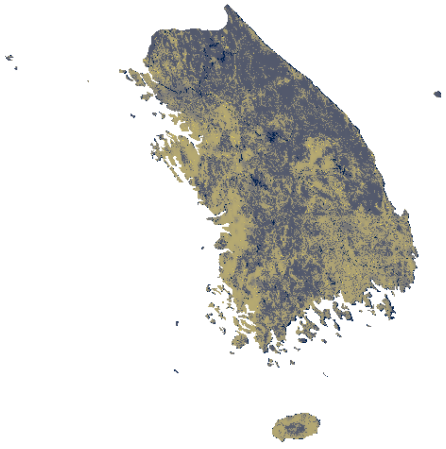

Fig 3-3 Spring crop pollination for SSP2 2040

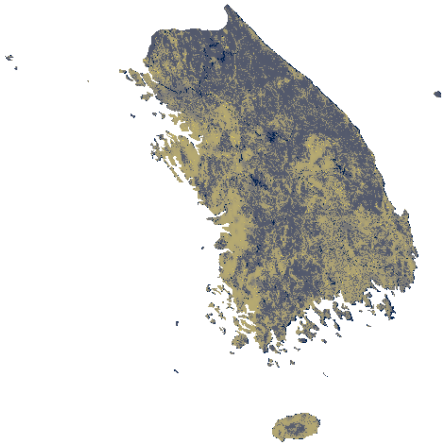

Fig 3-4 Spring crop pollination for SSP3 2030

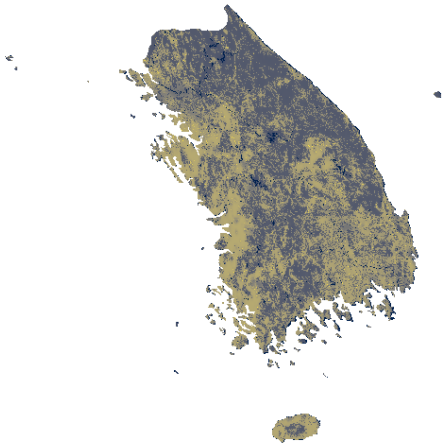

Fig 3-5 Spring crop pollination for SSP3 2035

Fig 3-6 Spring crop pollination for SSP3 2040

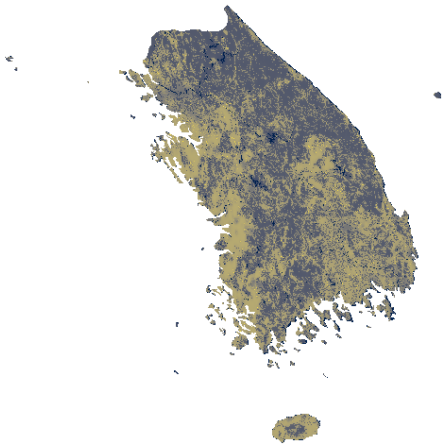

Fig 3-7 Spring crop pollination for SSP2 2030 under policy

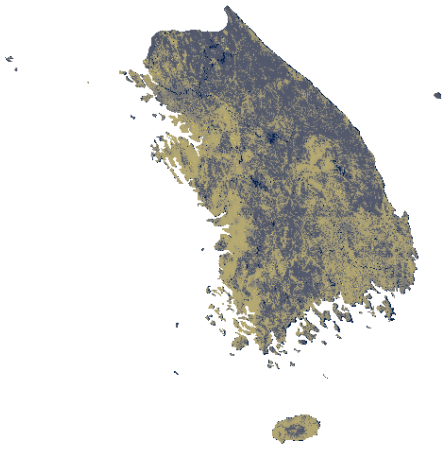

Fig 3-8 Spring crop pollination for SSP2 2035 under policy

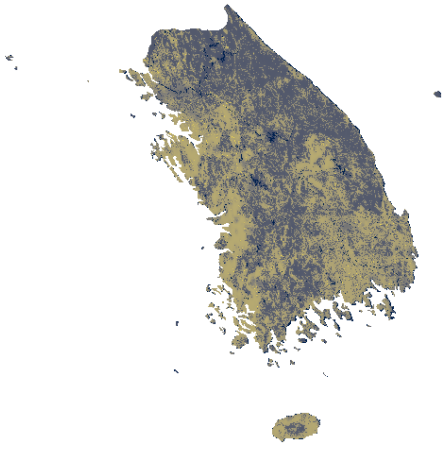

Fig 3-9 Spring crop pollination for SSP2 2040 under policy

There are some summaries:

1. Overall Change Between Different SSP2 Years

The analysis of the spring crop pollination data for SSP2 scenarios from 2030 to 2040 indicates that the mean pollination values remain relatively stable but slightly increase over the years. The standard deviations suggest modest changes in variability, hinting at slight adjustments in pollination effectiveness across different areas.

2. Regional Change Between Different SSP2 Years

The regional analysis for SSP2 shows minor differences in pollination across the southeast, southwest, northeast, and northwest regions. Each region exhibits a minimal change in mean values over the decade, with the northwest consistently showing slightly less negative mean values compared to other regions, possibly indicating better pollination outcomes in this area.

3. Overall Change Between Different SSP3 Years

For the SSP3 scenarios, the pattern is similar to SSP2, with a slight increase in mean pollination values from 2030 to 2040. This trend suggests a general improvement in pollination conditions under the SSP3 projections, although the changes are modest.

4. Regional Change Between Different SSP3 Years

Regional data for SSP3 also reflects stable pollination values with slight improvements over time. The northwest region maintains less negative mean values, similar to SSP2, indicating it might be less affected by factors that reduce pollination efficiency compared to other regions.

5. Overall Change Between Different SSP2 Under the Policy (No Agricultural Land Change)

Under the policy scenarios where agricultural land changes are restricted, the pollination values show a trend similar to the non-policy scenarios. This indicates that the policy may not have a significant direct impact on pollination rates, at least not in a way that drastically differs from the natural progression observed in other scenarios.

6. Regional Change Between Different SSP2 Under the Policy (No Agricultural Land Change)

In the policy-constrained scenarios, regional trends mirror the general observations: minimal changes with a slight improvement over time. The northwest continues to show the least negative impacts, suggesting some regional resilience or factors that favor better pollination outcomes.

Overall Summarization

The analysis across different SSP scenarios and policy constraints reveals a generally stable condition for spring crop pollination, with slight improvements over the decade from 2030 to 2040. While the overall changes are modest, regional analysis indicates that the northwest consistently fares better in terms of pollination compared to other regions. This could suggest regional differences in environmental conditions or agricultural practices that affect pollination. The policy restriction on agricultural land changes does not seem to significantly alter the trajectory of pollination outcomes, suggesting that other environmental or agricultural factors might play more crucial roles in influencing these trends.

Sediment Delivery Ratio

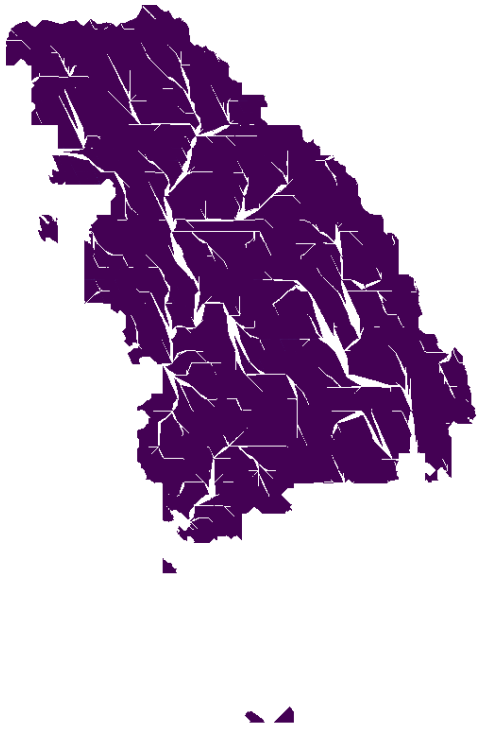

Fig 4-1 Sediment Delivery Ratio for SSP2 2030

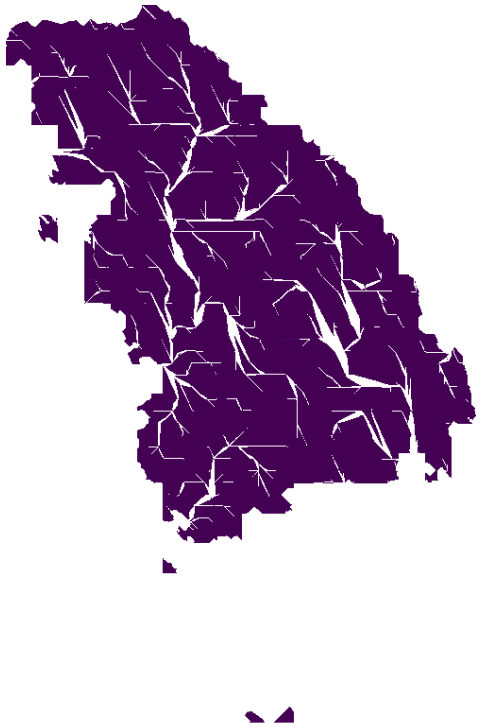

Fig 4-2 Sediment Delivery Ratio for SSP2 2035

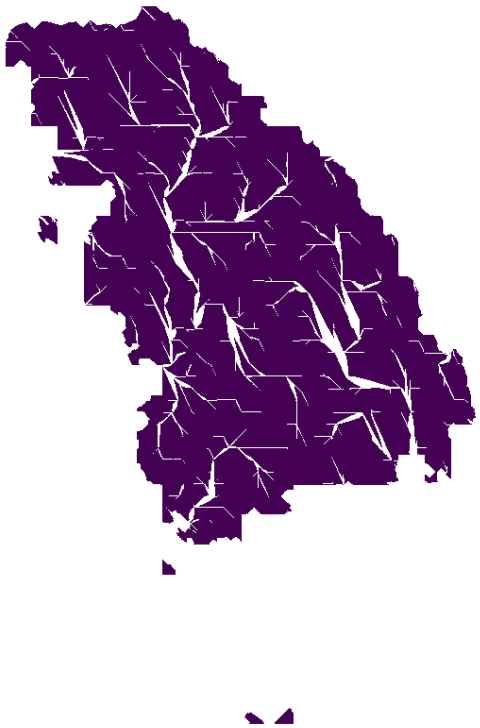

Fig 4-3 Sediment Delivery Ratio for SSP2 2040

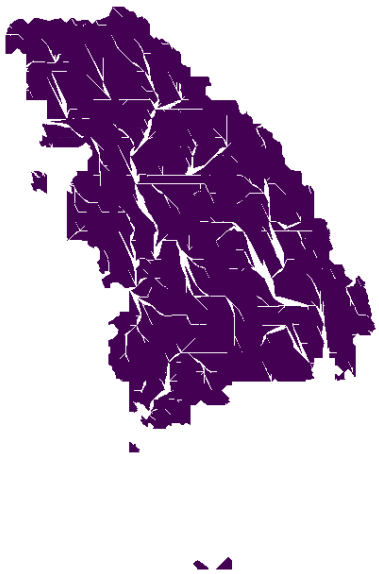

Fig 4-4 Sediment Delivery Ratio for SSP3 2030

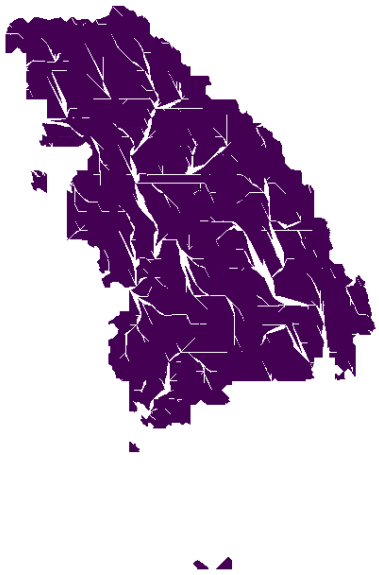

Fig 4-5 Sediment Delivery Ratio for SSP3 2035

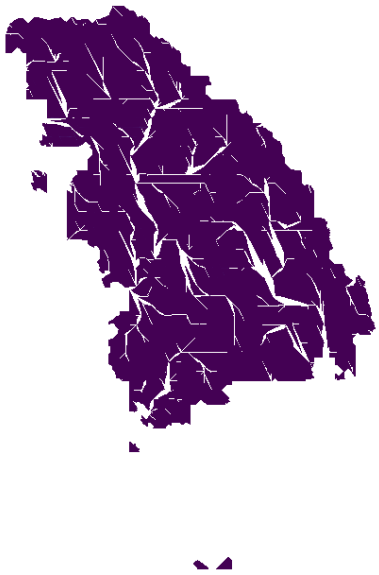

Fig 4- Sediment Delivery Ratio for SSP3 2040

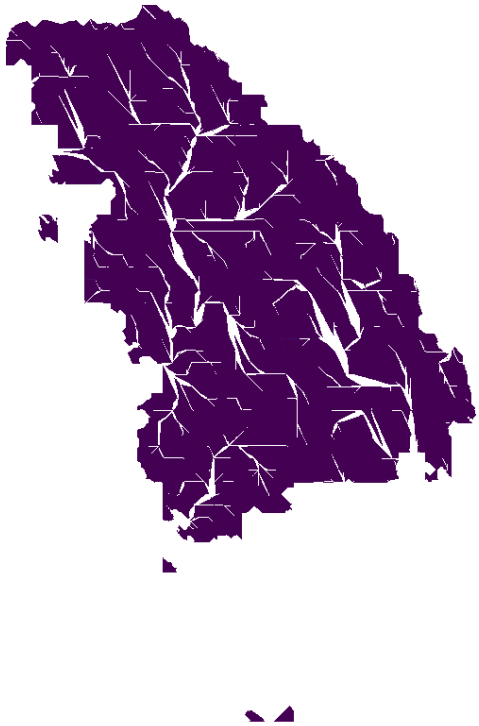

Fig 4-7 Sediment Delivery Ratio for SSP2 2030 under policy

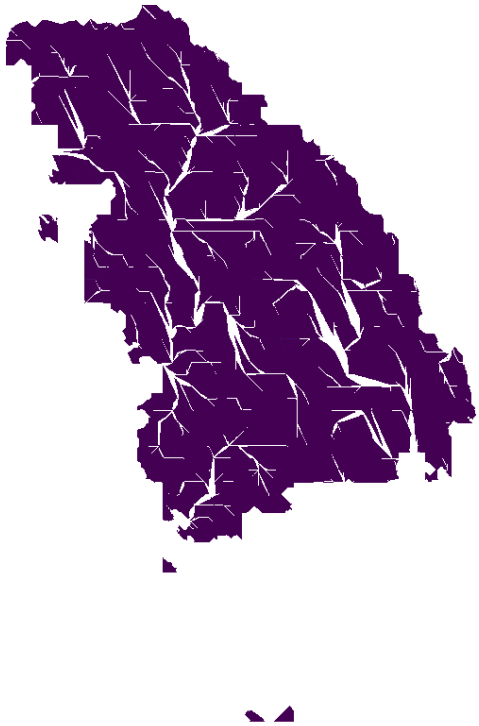

Fig 4-8 Sediment Delivery Ratio for SSP2 2035 under policy

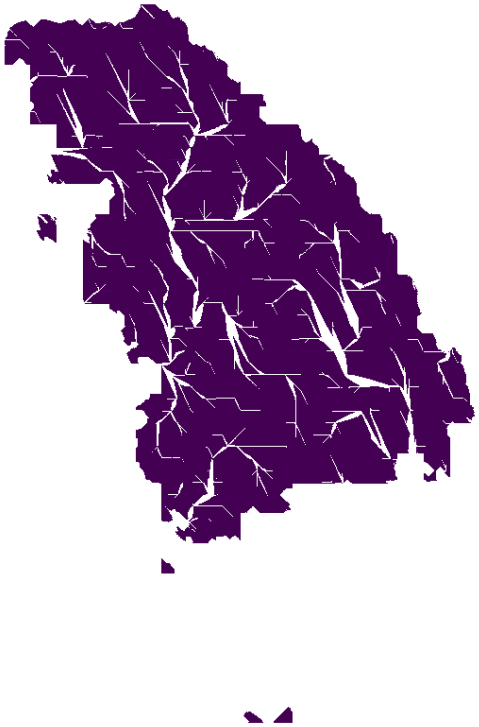

Fig 4-9 Sediment Delivery Ratio for SSP2 2040 under policy

There are some summaries：

1. Overall Change Between Different SSP2 Years

The analysis of Sediment Delivery Ratio (SDR) data for SSP2 scenarios across the years 2030, 2035, and 2040 shows consistently high values, often reaching the upper limits of data measurement (overflow to infinity). This suggests that sediment delivery is either extremely high or the data might be experiencing errors or overflow issues due to very high values.

2. Regional Change Between Different SSP2 Years

Regional analysis for SSP2 also shows infinite or extremely high values across all four regions: southeast, southwest, northeast, and northwest. Each region consistently hits the upper measurement limits, indicating robust sediment delivery across all areas without significant change over the decade.

3. Overall Change Between Different SSP3 Years

Similarly, the SSP3 scenarios show no variation over time with all the analyzed years presenting extremely high or infinite SDR values. This pattern across different SSP scenarios indicates a persistent high sediment delivery, suggesting strong environmental or geographical influences that maintain high SDR.

4. Regional Change Between Different SSP3 Years

The regional analysis for SSP3 mirrors that of SSP2, with all regions consistently showing extremely high values. This uniformity suggests that the conditions leading to high sediment delivery are widespread and not confined to specific regions.

5. Overall Change Between Different SSP2 Under the Policy (No Agricultural Land Change)

Even with policy interventions that restrict changes in agricultural land, the sediment delivery ratios remain at the upper limits across the 2030, 2035, and 2040 scenarios. This consistency implies that the policy does not have a significant impact on sediment delivery rates, possibly due to overriding natural or other anthropogenic factors.

6. Regional Change Between Different SSP2 Under the Policy (No Agricultural Land Change)

Under the policy scenarios, regional sediment delivery remains extremely high across all regions. This indicates that the policy's influence is minimal in altering regional patterns of sediment delivery, which are possibly dominated by factors such as terrain and climate conditions.

Overall Summarization

The analysis across different SSP scenarios and policy constraints consistently shows extremely high or infinite values for Sediment Delivery Ratio, indicating robust sediment transport across the studied years and scenarios. The uniformity of results across different regions and under policy constraints suggests that factors leading to high sediment delivery are pervasive and possibly dominated by geographical and natural conditions rather than policy or land management changes. This could highlight the need for revisiting measurement scales or methods to better capture variations in sediment delivery under different scenarios.

Nutrient Delivery Ratio

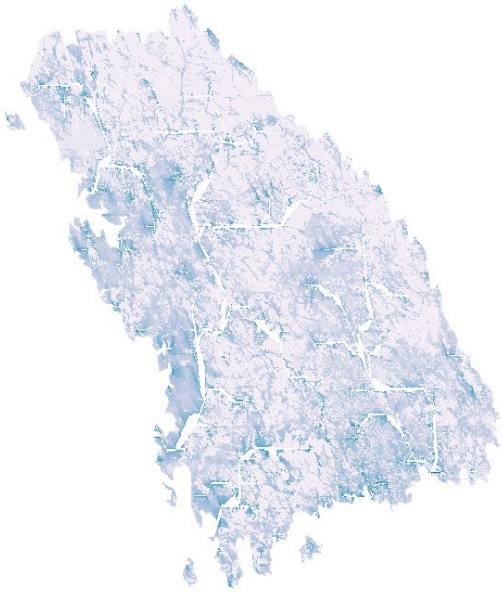

Fig 5-1 Nutrient Delivery Ratio for SSP2 2030

Fig 5-2 Nutrient Delivery Ratio for SSP2 2035

Fig 5-3 Nutrient Delivery Ratio for SSP2 2040

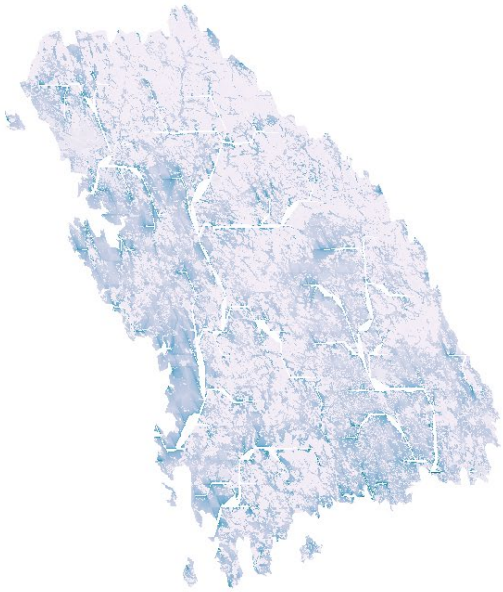

Fig 5-4 Nutrient Delivery Ratio for SSP3 2030

Fig 5-5 Nutrient Delivery Ratio for SSP3 2035

Fig 5-6 Nutrient Delivery Ratio for SSP3 2040

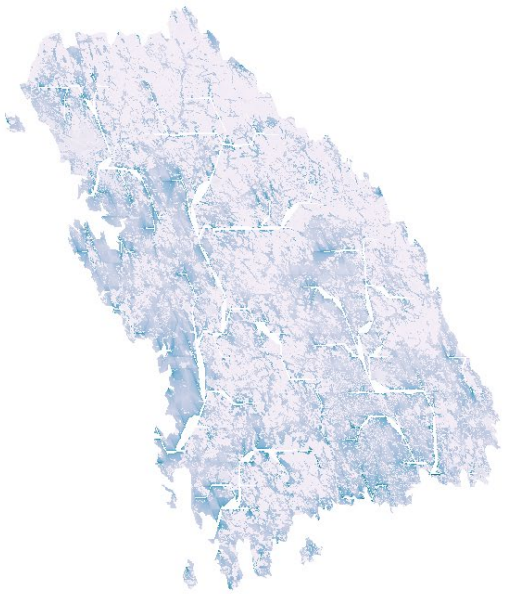

Fig 5-7 Nutrient Delivery Ratio for SSP2 2030 under policy

Fig 5-8 Nutrient Delivery Ratio for SSP2 2035 under policy

Fig 5-9 Nutrient Delivery Ratio for SSP2 2040 under policy

There are some summaries：

1. Overall Change Between Different SSP2 Years

The overall trend for Nutrient Delivery Ratio (NDR) in SSP2 scenarios indicates a gradual increase from 2030 to 2040. This suggests that conditions promoting nutrient delivery are improving over time, potentially due to changes in agricultural practices, land use, or climate conditions that enhance nutrient transport.

2. Regional Change Between Different SSP2 Years

Regionally, there's a clear distinction between areas:

Southeast and Northeast consistently show positive increases, suggesting good nutrient delivery that improves slightly over time.

Northwest exhibits moderate values but also shows improvement, indicating better nutrient management or environmental conditions conducive to nutrient delivery.

Southwest, however, consistently shows negative values, indicating poor nutrient delivery, which may be due to local conditions or management practices that inhibit effective nutrient transport.

3. Overall Change Between Different SSP3 Years

Similar to SSP2, the SSP3 scenarios also show a slight upward trend in NDR values from 2030 to 2040. This indicates that the underlying factors affecting nutrient delivery are similar across different shared socioeconomic pathways, pointing towards broader environmental or policy-driven improvements.

4. Regional Change Between Different SSP3 Years

The regional trends in SSP3 closely mirror those observed in SSP2:

Both Southeast and Northeast regions show consistently positive and improving nutrient delivery.

Northwest demonstrates modest improvements.

Southwest remains an area of concern with consistently low or negative values, suggesting challenges in nutrient delivery.

5. Overall Change Between Different SSP2 Under the Policy (No Agricultural Land Change)

Under policy scenarios that restrict changes in agricultural land use, there's still a positive trend observed in NDR from 2030 to 2040. This indicates that even without changes to land use, improvements in nutrient delivery can be achieved, likely through better management practices or technological advancements.

6. Regional Change Between Different SSP2 Under the Policy (No Agricultural Land Change)

Regional analysis under the policy constraints shows similar patterns to those without policy changes:

Southeast and Northeast continue to perform well.

Northwest shows consistent improvement.

Southwest continues to lag behind, highlighting the need for specific regional interventions to enhance nutrient delivery.

Overall Summarization

The analysis across SSP2, SSP3, and policy scenarios indicates a general improvement in Nutrient Delivery Ratios from 2030 to 2040, suggesting effective management and environmental conditions conducive to nutrient delivery are being established over time. Regional disparities, particularly the poor performance in the Southwest, highlight areas where further intervention may be necessary. The consistency of improvement across different scenarios and policies suggests robust underlying factors that support nutrient delivery, independent of changes in agricultural land use. This robustness is encouraging for future nutrient management strategies, though the regional disparities indicate a need for tailored approaches in specific areas.

Part d Executive Summary:

Our analysis of ecosystem services under various SSP scenarios and policy constraints reveals key insights for policymakers focused on green economic development. Across the board, we observe a slight but consistent increase in water yield and improvements in nutrient delivery ratios from 2030 to 2040, suggesting an overall enhancement in these vital ecosystem services. However, challenges persist, notably in sediment delivery, which consistently reaches extremely high values, and regional disparities in nutrient delivery, particularly the persistent underperformance in the Southwest. The implementation of a no agricultural land change policy does not significantly alter these trends, indicating that other environmental or technological factors may play a more pivotal role. For policymakers, these findings underscore the importance of tailored regional strategies that address specific environmental management needs while fostering green economic growth. The stability and slight improvement in ecosystem services, despite varying socio-economic scenarios and stringent policy measures, provide a hopeful outlook for sustaining and enhancing the country's ecological assets as part of broader economic development goals.