In [1]:

```
import pandas as pd

file_path = "C:\\Users\\Rishab\\Documents\\UCL\\Masters Thesis\\Relevant journals\\Alter

df = pd.read_excel(file_path)

print(df)
```

```
8   2031              Y10
9   2032              Y11
10  2033              Y12
11  2034              Y13
12  2035              Y14
13  2036              Y15

    New total carbon revenue, after temperature loss (30USD/tonne)  \
0                                          2.519933e+04
1                                          3.841754e+05
2                                          1.040960e+06
3                                          1.027454e+06
4                                          1.028948e+06
5                                          1.015439e+06
6                                          1.031935e+06
7                                          1.033425e+06
8                                          9.922957e+05
9                                          1.036479e+06
10                                         1.007973e+06
11                                         1.024468e+06
```

In [33]:

```
#Scenario 3 50%
import pandas as pd
import matplotlib.pyplot as plt

file_path = "C:\\Users\\Rishab\\Documents\\UCL\\Masters Thesis\\Relevant journals\\Alter

df = pd.read_excel(file_path)

#  probabilities for each variable in column number
prob_3 = 0.5
prob_4 = 0.5
prob_5 = 0.5
prob_6 = 1.0  # Probability is 100%

#  expected value for each scenario
df["Expected_Value_3"] = df["New total carbon revenue, after temperature loss (30USD/ton
df["Expected_Value_4"] = df["New total carbon revenue, after precipitation gain Mangrove
df["Expected_Value_5"] = df["New total carbon revenue, after precipitation loss Seagrass
df["Expected_Value_6"] = df["New total carbon revenue, after Lidar gain Mangroves 50% ma

#  overall expected value for each row
df["Overall_Expected_Value"] = df["Annual Carbon Credits Revenue (USD)"]-df["Expected_Va

#  percentage change from the initial value
initial_value = df["Overall_Expected_Value"].iloc[0]
df["Percent_Change"] = ((df["Overall_Expected_Value"] - initial_value) / initial_value)

# DataFrame with calculated expected values
print(df)




#  line plots
plt.figure(figsize=(10, 6))
plt.plot(df["Overall_Expected_Value"], label="Overall Expected Value")
plt.title("Overall Expected Value (50% Probability: All variables)")
plt.xlabel("Year")
plt.ylabel("Revenue per year")
plt.legend()
plt.show()

plt.figure(figsize=(10, 6))
plt.plot(df["Overall_Expected_Value"], label="Overall Expected Value")
plt.plot(df["Percent_Change"], label="% Change")
plt.title("Overall % Change (50% Probability: All variables except Lidar)")
plt.xlabel("Year")
plt.ylabel("Value")
plt.legend()
plt.show()
```

```
8                  1.033567e+06     103852.170100      20754.849575
9                  1.063021e+06      81760.695419      19728.571326
10                 1.045930e+06      96013.301307      19319.960381
11                 1.047156e+06      87766.172986      24400.565817
12                 1.057072e+06      79519.956306      24622.104283
13                 1.055431e+06      86272.776414      20816.318667

    Expected_Value_5  Expected_Value_6  Overall_Expected_Value  Percent
_Change
0         821.057165             95.85            2.735746e+04
0.000000
1       15555.247113           1437.75            4.121204e+05     140
6.427901
2       41853.740914           3834.00            1.107082e+06     394
6.729612
3       35386.279796           3834.00            1.102991e+06     393
1.775209
4       37783.054025           3834.00            1.102751e+06     393
0.897615
5       40825.616012           3834.00            1.094744e+06     390
```

In [35]:

```
#Scenario 3 100%
import pandas as pd
import matplotlib.pyplot as plt

file_path = "C:\\Users\\Rishab\\Documents\\UCL\\Masters Thesis\\Relevant journals\\Alter

df = pd.read_excel(file_path)


prob_3 = 1.0
prob_4 = 1.0
prob_5 = 1.0
prob_6 = 1.0



df["Expected_Value_3"] = df["New total carbon revenue, after temperature loss (30USD/ton
df["Expected_Value_4"] = df["New total carbon revenue, after precipitation gain Mangrove
df["Expected_Value_5"] = df["New total carbon revenue, after precipitation loss Seagrass
df["Expected_Value_6"] = df["New total carbon revenue, after Lidar gain Mangroves 50% ma


df["Overall_Expected_Value"] = df["Annual Carbon Credits Revenue (USD)"]-df["Expected_Va


initial_value = df["Overall_Expected_Value"].iloc[0]
df["Percent_Change"] = ((df["Overall_Expected_Value"] - initial_value) / initial_value)


print(df)







plt.figure(figsize=(10, 6))
plt.plot(df["Overall_Expected_Value"], label="Overall Expected Value")
plt.title("Overall Expected Value(100% Probability: All variables)")

plt.xlabel("Year")
plt.ylabel("Revenue per year")
plt.legend()
plt.show()

plt.figure(figsize=(10, 6))
plt.plot(df["Percent_Change"], label="% Change")
plt.title("Overall Expected Value (100% Probability: All variables)")
plt.xlabel("Year")
plt.ylabel("Value")
plt.legend()
plt.show()

result_df = df[["Year", "Overall_Expected_Value", "Percent_Change"]]


output_file_path = "output_data1.xlsx"
result_df.to_excel(output_file_path, index=False)
```

```
print(f"Data exported to {output_file_path}")
```

```
0                   2.614825e+04        4800.665065         965.998019
1                   3.926834e+05       65824.629740       18300.424363
2                   1.057072e+06      159039.912611       49244.208565
3                   1.055431e+06      172545.552827       41632.637334
4                   1.053844e+06      171052.373944       44452.831814
5                   1.042202e+06      184560.588756       48031.260234
6                   1.062867e+06      168064.658997       36445.818643
7                   1.046598e+06      166575.353324       55691.393541
8                   1.033567e+06      207704.340199       41509.699149
9                   1.063021e+06      163521.390837       39457.142652
10                  1.045930e+06      192026.602613       38639.920761
11                  1.047156e+06      175532.345973       48801.131634
12                  1.057072e+06      159039.912611       49244.208565
13                  1.055431e+06      172545.552827       41632.637334

    Expected_Value_5  Expected_Value_6  Overall_Expected_Value  Percent
_Change
0        1642.114331             95.85            2.461907e+04
0.000000
1       31110.494225           1437.75            3.728031e+05      141
```

In [36]:

```
#Scenario 2 50%
import pandas as pd
import matplotlib.pyplot as plt

file_path = "C:\\Users\\Rishab\\Documents\\UCL\\Masters Thesis\\Relevant journals\\Alter

df = pd.read_excel(file_path)


prob_3 = 0.5
prob_4 = 0.5
prob_5 = 0.5



df["Expected_Value_3"] = df["New total carbon revenue, after temperature loss (30USD/ton
df["Expected_Value_4"] = df["New total carbon revenue, after precipitation gain Mangrove
df["Expected_Value_5"] = df["New total carbon revenue, after precipitation loss Seagrass



df["Overall_Expected_Value"] = df["Annual Carbon Credits Revenue (USD)"]-df["Expected_Va

initial_value = df["Overall_Expected_Value"].iloc[0]
df["Percent_Change"] = ((df["Overall_Expected_Value"] - initial_value) / initial_value)


print(df)







plt.figure(figsize=(10, 6))
plt.plot(df["Overall_Expected_Value"], label="Overall Expected Value")
plt.title("Overall Expected Value (50% Probability: Precipitation and temperature only)"
plt.xlabel("Year")
plt.ylabel("Revenue per year")
plt.legend()
plt.show()
```

5	1.042202e+06	92280.294378	24015.630117
6	1.062867e+06	84032.329498	18222.909322
7	1.046598e+06	83287.676662	27845.696771
8	1.033567e+06	103852.170100	20754.849575
9	1.063021e+06	81760.695419	19728.571326
10	1.045930e+06	96013.301307	19319.960381
11	1.047156e+06	87766.172986	24400.565817
12	1.057072e+06	79519.956306	24622.104283
13	1.055431e+06	86272.776414	20816.318667

	Expected_Value_5	Overall_Expected_Value	Percent_Change
0	821.057165	2.726161e+04	0.000000
1	15555.247113	4.106827e+05	1406.450502
2	41853.740914	1.103248e+06	3946.893910
3	35386.279796	1.099157e+06	3931.886929
4	37783.054025	1.098917e+06	3931.006249
5	40825.616012	1.090910e+06	3901.633606
6	30977.079555	1.103214e+06	3946.765866
7	47335.790195	1.097222e+06	3924.788916
8	35280.854658	1.081622e+06	3867.564103

In [37]:

```
#Scenario 2 100%
import pandas as pd
import matplotlib.pyplot as plt

file_path = "C:\\Users\\Rishab\\Documents\\UCL\\Masters Thesis\\Relevant journals\\Alter

df = pd.read_excel(file_path)


prob_3 = 1.0
prob_4 = 1.0
prob_5 = 1.0

df["Expected_Value_3"] = df["New total carbon revenue, after temperature loss (30USD/ton
df["Expected_Value_4"] = df["New total carbon revenue, after precipitation gain Mangrove
df["Expected_Value_5"] = df["New total carbon revenue, after precipitation loss Seagrass


df["Overall_Expected_Value"] = df["Annual Carbon Credits Revenue (USD)"]-df["Expected_Va


initial_value = df["Overall_Expected_Value"].iloc[0]
df["Percent_Change"] = ((df["Overall_Expected_Value"] - initial_value) / initial_value)


print(df)







plt.figure(figsize=(10, 6))
plt.plot(df["Overall_Expected_Value"], label="Overall Expected Value")
plt.title("Overall Expected Value (100% Probability: Precipitation and temperature only)
plt.xlabel("Year")
plt.ylabel("Revenue per year")
plt.legend()
plt.show()

#  new DataFrame containing the desired columns
result_df = df[["Year", "Overall_Expected_Value", "Percent_Change"]]


output_file_path = "output_data.xlsx"
result_df.to_excel(output_file_path, index=False)


print(f"Data exported to {output_file_path}")
```

10	1.045930e+06	192026.602613	38639.920761
11	1.047156e+06	175532.345973	48801.131634
12	1.057072e+06	159039.912611	49244.208565
13	1.055431e+06	172545.552827	41632.637334

	Expected_Value_5	Overall_Expected_Value	Percent_Change
0	1642.114331	2.452322e+04	0.000000
1	31110.494225	3.713653e+05	1414.341596
2	83707.481827	1.006497e+06	4004.260658
3	70772.559593	9.983145e+05	3970.895180
4	75566.108051	9.978343e+05	3968.937137
5	81651.232025	9.818194e+05	3903.632046
6	61954.159110	1.006427e+06	4003.975975
7	94671.580390	9.944445e+05	3955.113952
8	70561.709315	9.632436e+05	3827.884282
9	67064.508462	1.008871e+06	4013.943030
10	65684.573235	9.809287e+05	3900.000000
11	82961.317934	9.903075e+05	3938.244257
12	83707.481827	1.006497e+06	4004.260658
13	70772.559593	9.983145e+05	3970.895180

In [38]:

```
#Scenario 1 100% probability
import pandas as pd
import matplotlib.pyplot as plt

file_path = "C:\\Users\\Rishab\\Documents\\UCL\\Masters Thesis\\Relevant journals\\Alter

df = pd.read_excel(file_path)



prob_6 = 1.0  # Probability is 100%


df["Expected_Value_6"] = df["New total carbon revenue, after Lidar gain Mangroves 50% ma

df["Overall_Expected_Value"] = df["Annual Carbon Credits Revenue (USD)"]+df["Expected_Va
# Calculating the percentage change from the initial value
initial_value = df["Overall_Expected_Value"].iloc[0]
df["Percent_Change"] = ((df["Overall_Expected_Value"] - initial_value) / initial_value)

# Print the DataFrame with calculated expected values
print(df)




plt.figure(figsize=(10, 6))
plt.plot(df["Overall_Expected_Value"], label="Overall Expected Value")
plt.title("Overall Expected Value(100% Probability: Lidar only)")

plt.xlabel("Year")
plt.ylabel("Revenue per year")
plt.legend()
plt.show()

plt.figure(figsize=(10, 6))
plt.plot(df["Percent_Change"], label="% Change")
plt.title("Overall Expected Value(100% Probability: Lidar only)")
plt.xlabel("Year")
plt.ylabel("Value")
plt.legend()
plt.show()
```

```
    Year BCS project Year  \
0   2023               Y2
1   2024               Y3
2   2025               Y4
3   2026               Y5
4   2027               Y6
5   2028               Y7
6   2029               Y8
7   2030               Y9
8   2031              Y10
9   2032              Y11
10  2033              Y12
11  2034              Y13
12  2035              Y14
13  2036              Y15

    New total carbon revenue, after temperature loss (30USD/tonne)  \
0                                          4800.665065
1                                         65824.629740
```

In [ ]:

```python
# new DataFrame containing the desired columns
result_df = df[["Year", "Overall_Expected_Value", "Percent_Change"]]

#  DataFrame to an Excel file
output_file_path = "output_data.xlsx"
result_df.to_excel(output_file_path, index=False)

# Display messageshowing successful export
print(f"Data exported to {output_file_path}")
```

In [39]:

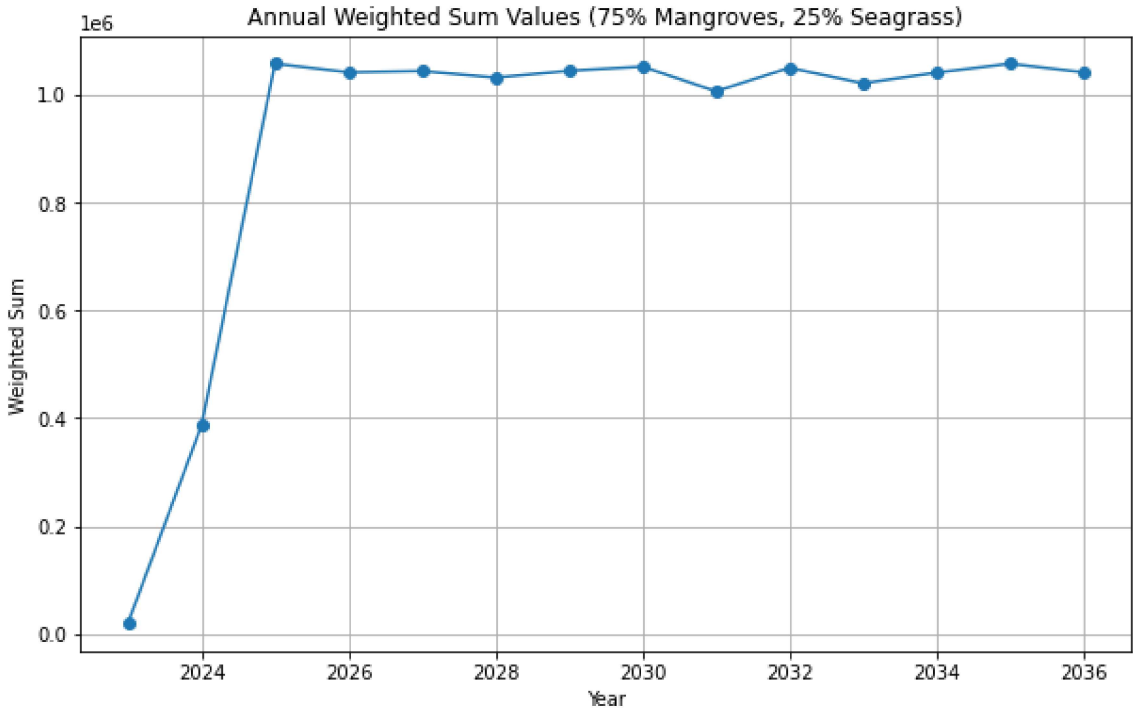
```
#Scenario 1 50% Probability
import pandas as pd
import matplotlib.pyplot as plt

file_path = "C:\\Users\\Rishab\\Documents\\UCL\\Masters Thesis\\Relevant journals\\Alter

df = pd.read_excel(file_path)



prob_6 = 0.5  # Probability is 50%



df["Expected_Value_6"] = df["New total carbon revenue, after Lidar gain Mangroves 50% ma
#  overall expected value for each row
df["Overall_Expected_Value"] = df["Annual Carbon Credits Revenue (USD)"] + df["Expected_

# percentage change from the initial value
initial_value = df["Overall_Expected_Value"].iloc[0]
df["Percent_Change"] = ((df["Overall_Expected_Value"] - initial_value) / initial_value)


print(df)







plt.figure(figsize=(10, 6))
plt.plot(df["Overall_Expected_Value"], label="Overall Expected Value")
plt.title("Overall Expected Value(50% Probability: Lidar only)")

plt.xlabel("Year")
plt.ylabel("Revenue per year")
plt.legend()
plt.show()

plt.figure(figsize=(10, 6))
plt.plot(df["Percent_Change"], label="% Change")
plt.title("Overall Expected Value(100% Probability: Lidar only)")
plt.xlabel("Year")
plt.ylabel("Value")
plt.legend()
plt.show()
```

```
6                 1.062867e+06          1917.000             1201917.0
00
7                 1.046598e+06          1917.000             1201917.0
00
8                 1.033567e+06          1917.000             1201917.0
00
9                 1.063021e+06          1917.000             1201917.0
00
10                1.045930e+06          1917.000             1201917.0
00
11                1.047156e+06          1917.000             1201917.0
00
12                1.057072e+06          1917.000             1201917.0
00
13                1.055431e+06          1917.000             1201917.0
00

    Percent_Change
0              0.0
1           1400.0
```

In [5]:

```
#MOO weighted sum 75% mangrove, 25% seagrass

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt


file_path = "C:\\Users\\Rishab\\Documents\\UCL\\Masters Thesis\\Relevant journals\\Alter
df = pd.read_excel(file_path)

# weights for the objectives
weight_1 = 0.75  # Objective 1 weight
weight_2 = 0.25  # Objective 2 weight

#  revenue for both objectives
revenue_1 = (df["Annual Carbon Credits Revenue (USD)"]) - \
            (df["New total carbon revenue, after temperature loss (30USD/tonne)"]) + \
            (df["New total carbon revenue, after precipitation gain Mangroves (30USD/ton
            (df["New total carbon revenue, after Lidar gain Mangroves, no distribution a
            (df["Lidar Cost"])

revenue_2 = (df["Annual Carbon Credits Revenue (USD)"]) - \
            (df["New total carbon revenue, after temperature loss (30USD/tonne)"]) - \
            (df["New total carbon revenue, after precipitation loss Seagrass (30USD/tonn

#  weighted sum of the objectives for each year
weighted_sum_per_year = (weight_1 * revenue_1) + (weight_2 * revenue_2)

# Add the weighted sum results to the DataFrame
df["Weighted_Sum"] = weighted_sum_per_year

#DataFrame for annual values
annual_values_df = pd.DataFrame({
    "Year": df["Year"],
    "Annual_Carbon_Credits_Revenue": df["Annual Carbon Credits Revenue (USD)"],
    "Weighted_Sum": weighted_sum_per_year
})

# Exportiing the annual values DataFrame toExcel file
output_file_path = "Annual_Values0.xlsx"
annual_values_df.to_excel(output_file_path, index=False)
print("Annual values exported to:", output_file_path)

# Plotting the annual weighted sum values
plt.figure(figsize=(10, 6))
plt.plot(df["Year"], df["Weighted_Sum"], marker='o')
plt.title("Annual Weighted Sum Values (75% Mangroves, 25% Seagrass)")
plt.xlabel("Year")
plt.ylabel("Weighted Sum")
plt.grid(True)
plt.show()

# Find  year with the best weighted sum
best_year_index = np.argmax(weighted_sum_per_year)
best_weighted_sum = weighted_sum_per_year[best_year_index]
best_year = df["Year"].iloc[best_year_index]

print("Best Year:", best_year)
print("Best Weighted Sum:", best_weighted_sum)
```

```
Annual values exported to: Annual_Values0.xlsx
```



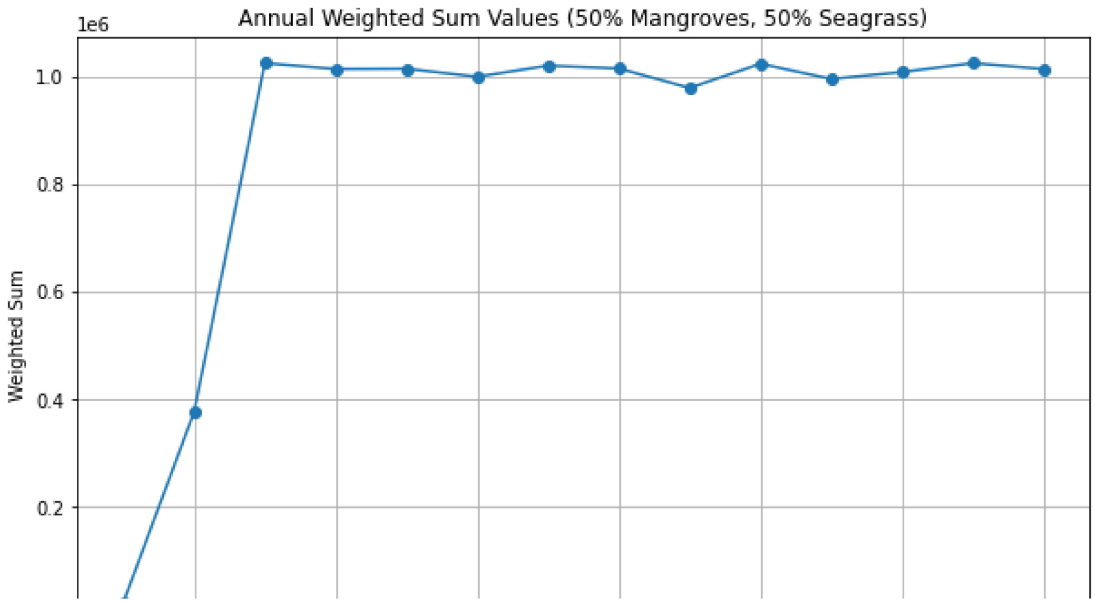

```
Best Year: 2025
Best Weighted Sum: 1057092.3733558718
```

In [6]:

```
#MOO weighted sum 50% mangrove, 50% seagrass


import pandas as pd
import numpy as np
import matplotlib.pyplot as plt


file_path = "C:\\Users\\Rishab\\Documents\\UCL\\Masters Thesis\\Relevant journals\\Alter
df = pd.read_excel(file_path)


weight_1 = 0.50  # Objective 1 weight
weight_2 = 0.50  # Objective 2 weight


revenue_1 = (df["Annual Carbon Credits Revenue (USD)"]) - \
            (df["New total carbon revenue, after temperature loss (30USD/tonne)"]) + \
            (df["New total carbon revenue, after precipitation gain Mangroves (30USD/ton
            (df["New total carbon revenue, after Lidar gain Mangroves, no distribution a
            (df["Lidar Cost"])

revenue_2 = (df["Annual Carbon Credits Revenue (USD)"]) - \
            (df["New total carbon revenue, after temperature loss (30USD/tonne)"]) - \
            (df["New total carbon revenue, after precipitation loss Seagrass (30USD/tonn


weighted_sum_per_year = (weight_1 * revenue_1) + (weight_2 * revenue_2)


df["Weighted_Sum"] = weighted_sum_per_year


annual_values_df = pd.DataFrame({
    "Year": df["Year"],
    "Annual_Carbon_Credits_Revenue": df["Annual Carbon Credits Revenue (USD)"],
    "Weighted_Sum": weighted_sum_per_year
})


output_file_path = "Annual_Values2.xlsx"
annual_values_df.to_excel(output_file_path, index=False)
print("Annual values exported to:", output_file_path)


plt.figure(figsize=(10, 6))
plt.plot(df["Year"], df["Weighted_Sum"], marker='o')
plt.title("Annual Weighted Sum Values (50% Mangroves, 50% Seagrass)")
plt.xlabel("Year")
plt.ylabel("Weighted Sum")
plt.grid(True)
plt.show()


best_year_index = np.argmax(weighted_sum_per_year)
best_weighted_sum = weighted_sum_per_year[best_year_index]
best_year = df["Year"].iloc[best_year_index]

print("Best Year:", best_year)
```

```
print("Best Weighted Sum:", best_weighted_sum)
```

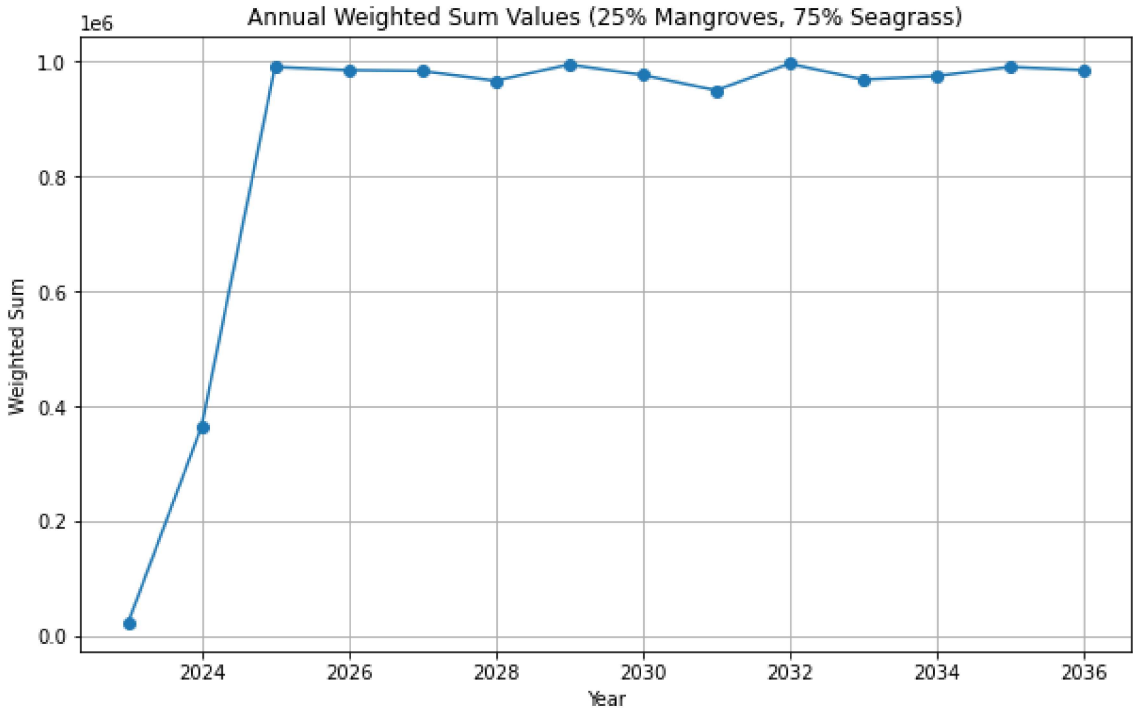
```
Annual values exported to: Annual_Values2.xlsx
```



In [7]:

```
#MOO weighted sum 25% mangrove, 75% seagrass

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt


file_path = "C:\\Users\\Rishab\\Documents\\UCL\\Masters Thesis\\Relevant journals\\Alter
df = pd.read_excel(file_path)


weight_1 = 0.25  # Objective 1 weight
weight_2 = 0.75  # Objective 2 weight


revenue_1 = (df["Annual Carbon Credits Revenue (USD)"]) - \
            (df["New total carbon revenue, after temperature loss (30USD/tonne)"]) + \
            (df["New total carbon revenue, after precipitation gain Mangroves (30USD/ton
            (df["New total carbon revenue, after Lidar gain Mangroves, no distribution a
            (df["Lidar Cost"])

revenue_2 = (df["Annual Carbon Credits Revenue (USD)"]) - \
            (df["New total carbon revenue, after temperature loss (30USD/tonne)"]) - \
            (df["New total carbon revenue, after precipitation loss Seagrass (30USD/tonn


weighted_sum_per_year = (weight_1 * revenue_1) + (weight_2 * revenue_2)


df["Weighted_Sum"] = weighted_sum_per_year


annual_values_df = pd.DataFrame({
    "Year": df["Year"],
    "Annual_Carbon_Credits_Revenue": df["Annual Carbon Credits Revenue (USD)"],
    "Weighted_Sum": weighted_sum_per_year
})


output_file_path = "Annual_Values3.xlsx"
annual_values_df.to_excel(output_file_path, index=False)
print("Annual values exported to:", output_file_path)

#  annual weighted sum values
plt.figure(figsize=(10, 6))
plt.plot(df["Year"], df["Weighted_Sum"], marker='o')
plt.title("Annual Weighted Sum Values (25% Mangroves, 75% Seagrass)")
plt.xlabel("Year")
plt.ylabel("Weighted Sum")
plt.grid(True)
plt.show()

# year with the best weighted sum
best_year_index = np.argmax(weighted_sum_per_year)
best_weighted_sum = weighted_sum_per_year[best_year_index]
best_year = df["Year"].iloc[best_year_index]

print("Best Year:", best_year)
print("Best Weighted Sum:", best_weighted_sum)
```

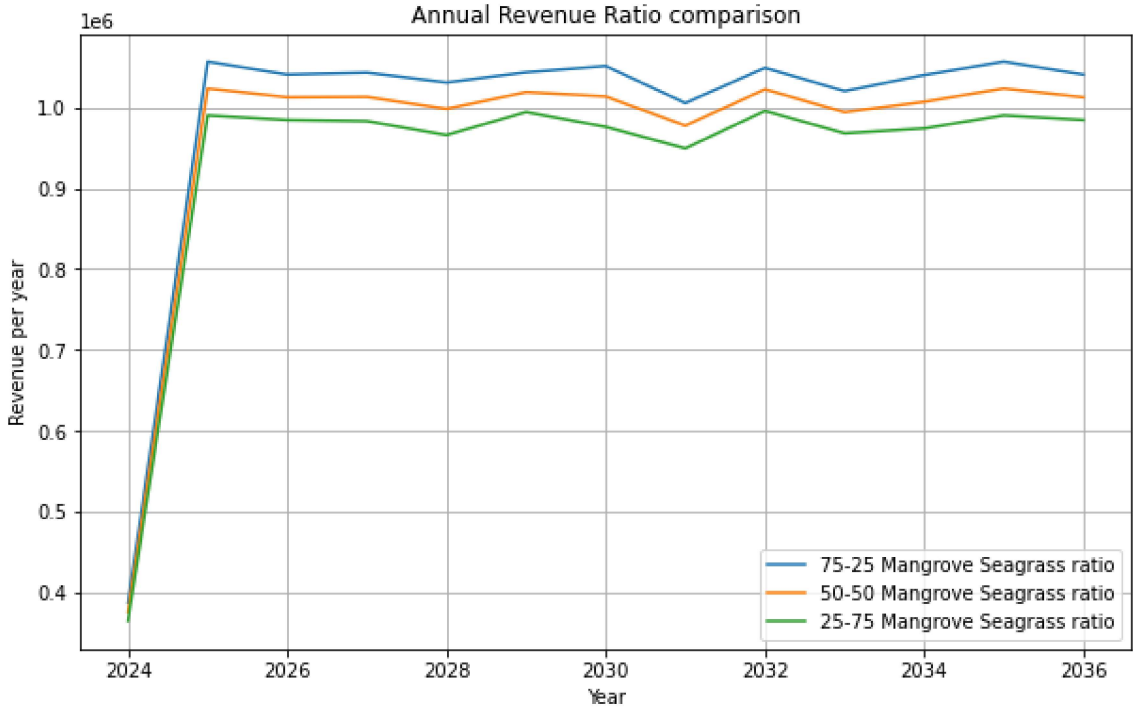
```
Annual values exported to: Annual_Values3.xlsx
```




```
Best Year: 2032
Best Weighted Sum: 996086.513478899
```

In [8]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt


file_path = "C:\\Users\\Rishab\\Documents\\UCL\\Masters Thesis\\Relevant journals\\Alter
df = pd.read_excel(file_path)

# Extract the valid data rows excluding the title row
data_rows = df.iloc[1:]

# Extract "Year" column as the x-axis
years = data_rows["Year"]

# Extract columns x, y, and z for plotting
column_x = data_rows["Weighted_Sum 75-25 MS ratio"]
column_y = data_rows["Weighted_Sum 50-50 MS ratio"]
column_z = data_rows["Weighted_Sum 25-75 MS ratio"]

#  line plot for columns x, y, and z with "Year" as the x-axis
plt.figure(figsize=(10, 6))
plt.plot(years, column_x, label="75-25 Mangrove Seagrass ratio")
plt.plot(years, column_y, label="50-50 Mangrove Seagrass ratio")
plt.plot(years, column_z, label="25-75 Mangrove Seagrass ratio")

plt.title("Annual Revenue Ratio comparison")
plt.xlabel("Year")
plt.ylabel("Revenue per year")
plt.legend()
plt.grid(True)
plt.show()

#  year with the best weighted sum
best_year_index = np.argmax(weighted_sum_per_year)
best_weighted_sum = weighted_sum_per_year[best_year_index]
best_year = df["Year"].iloc[best_year_index]
```


Annual Revenue Ratio comparison
1e6
Revenue per year
1.0
0.9
0.8
0.7
0.6
0.5
0.4
2024
2026
2028
2030
2032
2034
2036
Year
75-25 Mangrove Seagrass ratio
50-50 Mangrove Seagrass ratio
25-75 Mangrove Seagrass ratio

In [ ]: