import streamlit as st

import numpy as np

import pandas as pd

import io

# --- Page Config ---

st.set\_page\_config(page\_title="AHP Multi-Sector Evaluator", layout="centered")

# --- Constants ---

CRITERIA = [

    "Carbon Reduction Potential and Environmental Co-Benefits",

    "Economic Feasibility",

    "Technological Readiness and Implementation Feasibility",

    "Scalability and Long-Term Sustainability",

    "Policy Alignment",

    "Social Acceptance"

]

ALTERNATIVES = [

    "CCS / CCUS carbon capture and storage (filtre)",

    "Fuel Switching / Alternative Fuel Sources",

    "Reuse Waste Heat",

    "Sustainable Material Selection and Recycling",

    "Digitalization and Industry 4.0 Applications"

]

SECTORS = [

    "metal industries",

    "cement",

    "chemical production",

    "oil and gas",

    "critical mineral industry"

]

# --- AHP Logic ---

def pairwise\_matrix(items, session\_key):

    n = len(items)

    matrix = np.ones((n, n))

    for i in range(n):

        for j in range(i + 1, n):

            key = f"{session\_key}\_{i}\_{j}"

            col1, col2, col3 = st.columns([4, 2, 4])

            with col1:

                st.markdown(f"<div style='text-align:center; border:1px solid #ccc; padding:8px; border-radius:6px;'>{items[i]}</div>", unsafe\_allow\_html=True)

            with col2:

                val = st.slider(

                    label=" ",

                    min\_value=1,

                    max\_value=9,

                    value=1,

                    step=1,

                    key=key,

                    help="Slide toward the option you find more important."

                )

            with col3:

                st.markdown(f"<div style='text-align:center; border:1px solid #ccc; padding:8px; border-radius:6px;'>{items[j]}</div>", unsafe\_allow\_html=True)

            matrix[i][j] = val

            matrix[j][i] = 1 / val

    return matrix

def normalize\_matrix(matrix):

    col\_sum = np.sum(matrix, axis=0)

    return matrix / col\_sum

def calculate\_priority\_vector(matrix):

    norm = normalize\_matrix(matrix)

    return np.mean(norm, axis=1)

def consistency\_ratio(matrix, priority\_vector):

    n = len(priority\_vector)

    lamda\_max = np.sum(np.dot(matrix, priority\_vector) / priority\_vector) / n

    ci = (lamda\_max - n) / (n - 1)

    RI\_dict = {1: 0.0, 2: 0.0, 3: 0.58, 4: 0.9, 5: 1.12, 6: 1.24, 7: 1.32, 8: 1.41, 9: 1.45, 10: 1.49}

    ri = RI\_dict.get(n, 1.49)

    cr = ci / ri if ri != 0 else 0

    return cr

# --- Streamlit UI ---

st.title("🌍 AHP Multi-Sector Decarbonization Evaluator")

st.markdown("""

<div style='text-align: center;'>

    Welcome to the AHP application for evaluating decarbonization strategies across sectors.

    You'll walk through four steps to build a decision framework and receive a downloadable report.

</div>

""", unsafe\_allow\_html=True)

st.header("① Compare Evaluation Criteria")

with st.expander("Compare Criteria - Click to Expand"):

    st.write("Provide pairwise comparisons between the six evaluation criteria:")

    criteria\_matrix = pairwise\_matrix(CRITERIA, "criteria")

    criteria\_weights = calculate\_priority\_vector(criteria\_matrix)

    criteria\_cr = consistency\_ratio(criteria\_matrix, criteria\_weights)

    st.subheader("Criteria Weights")

    st.dataframe(pd.DataFrame({"Criteria": CRITERIA, "Weight": criteria\_weights}))

    st.markdown(f"\*\*Consistency Ratio (CR):\*\* `{criteria\_cr:.3f}`")

    if criteria\_cr > 0.1:

        st.warning("⚠️ The consistency ratio is high. Consider revisiting your judgments.")

st.header("② Sector-Wise Evaluation of Alternatives")

st.markdown("<div style='text-align:center;'>Evaluate alternatives for <strong>all sectors</strong> below:</div>", unsafe\_allow\_html=True)

if 'sector\_results' not in st.session\_state:

    st.session\_state.sector\_results = {}

sector\_best\_alternatives = {}

for sector in SECTORS:

    st.subheader(f"{sector.title()}")

    for criterion in CRITERIA:

        with st.expander(f"{criterion}"):

            matrix = pairwise\_matrix(ALTERNATIVES, f"{sector}\_{criterion}")

            weights = calculate\_priority\_vector(matrix)

            cr = consistency\_ratio(matrix, weights)

            df = pd.DataFrame({"Alternative": ALTERNATIVES, "Weight": weights})

            st.dataframe(df)

            st.markdown(f"\*\*Consistency Ratio (CR):\*\* `{cr:.3f}`")

            if cr > 0.1:

                st.warning("⚠️ Inconsistent comparison. Try adjusting the values.")

            st.session\_state.sector\_results[(sector, criterion)] = weights

st.header("③ Best Alternative per Sector")

sector\_final\_scores = {}

all\_sector\_scores = []

for sector in SECTORS:

    alt\_scores = np.zeros(len(ALTERNATIVES))

    for i, criterion in enumerate(CRITERIA):

        weights = st.session\_state.sector\_results.get((sector, criterion))

        if weights is not None:

            alt\_scores += criteria\_weights[i] \* weights

    sector\_final\_scores[sector] = alt\_scores

    best\_index = np.argmax(alt\_scores)

    sector\_best\_alternatives[sector] = ALTERNATIVES[best\_index]

    sector\_score\_df = pd.DataFrame({"Alternative": ALTERNATIVES, "Score": alt\_scores})

    sector\_score\_df["Sector"] = sector

    all\_sector\_scores.append(sector\_score\_df)

    st.success(f"✅ \*\*{sector.title()}\*\*: Best Alternative → \*\*{ALTERNATIVES[best\_index]}\*\*")

st.header("④ Final AHP Between Sectoral Winners")

final\_alts = [f"{SECTORS[i].title()}: {alt}" for i, alt in enumerate([sector\_best\_alternatives[sec] for sec in SECTORS])]

final\_matrix = pairwise\_matrix(final\_alts, "final")

final\_weights = calculate\_priority\_vector(final\_matrix)

final\_cr = consistency\_ratio(final\_matrix, final\_weights)

final\_df = pd.DataFrame({"Sector": SECTORS, "Best Alternative": [sector\_best\_alternatives[sec] for sec in SECTORS], "Weight": final\_weights})

st.dataframe(final\_df)

st.markdown(f"\*\*Final Consistency Ratio (CR):\*\* `{final\_cr:.3f}`")

if final\_cr > 0.1:

    st.warning("⚠️ High inconsistency in final AHP step.")

# --- Final Result Summary ---

st.header("🏆 Best of the Best")

best\_final\_index = np.argmax(final\_weights)

worst\_final\_index = np.argmin(final\_weights)

st.success(f"🏅 Best Overall Alternative: \*\*{final\_alts[best\_final\_index]}\*\* with score `{final\_weights[best\_final\_index]:.4f}`")

st.info(f"🔻 Lowest Ranked Alternative: \*\*{final\_alts[worst\_final\_index]}\*\* with score `{final\_weights[worst\_final\_index]:.4f}`")

st.header("⑤ Download Evaluation Report")

combined\_df = pd.concat(all\_sector\_scores, ignore\_index=True)

final\_df["Final Weight"] = final\_weights

buffer = io.BytesIO()

with pd.ExcelWriter(buffer, engine='xlsxwriter') as writer:

    pd.DataFrame({"Criteria": CRITERIA, "Weight": criteria\_weights}).to\_excel(writer, sheet\_name='Criteria Weights', index=False)

    combined\_df.to\_excel(writer, sheet\_name='Sector Scores', index=False)

    final\_df.to\_excel(writer, sheet\_name='Final Evaluation', index=False)

st.download\_button(

    label="📥 Download Excel Report",

    data=buffer,

    file\_name="AHP\_MultiSector\_Report.xlsx",

    mime="application/vnd.openxmlformats-officedocument.spreadsheetml.sheet"

)