In [31]:
```
import numpy as np
import os
from sklearn.metrics import confusion_matrix
import seaborn as sn; sn.set(font_scale=1.4)
from sklearn.utils import shuffle
import matplotlib.pyplot as plt
import cv2
import tensorflow as tf
from tqdm import tqdm
```

```
WARNING:tensorflow:From C:\Users\PC\AppData\Local\Programs\Python\Python310\lib\site-packages\keras\src\losses.py:2976: The name tf.losses.sparse_softmax_cross_entropy is deprecated. Please use tf.compat.v1.losses.sparse_softmax_cross_entropy instead.
```

In [5]:
```
class_names = ['mountain', 'street', 'glacier', 'buildings', 'sea', 'forest']
class_names_label = {class_name:i for i, class_name in enumerate(class_names)}

nb_classes = len(class_names)

print("class_names_label", class_names_label)
print("nb_classes", nb_classes)

IMAGE_SIZE = (150, 150)
```

```
class_names_label {'mountain': 0, 'street': 1, 'glacier': 2, 'buildings': 3, 'sea': 4, 'forest': 5}
nb_classes 6
```

In [32]:
```
def load_data():
    """
        Load the data:
            - 14,034 images to train the network.
            - 3,000 images to evaluate how accurately the network learned to classify
    """

    datasets = [r'C:\Users\PC\OneDrive\Desktop\seg_train',r'C:\Users\PC\OneDrive\Deskt
    output = []

    # Iterate through training and test sets
    for dataset in datasets:

        images = []
        labels = []

        print("Loading {}".format(dataset))

        # Iterate through each folder corresponding to a category
        for folder in os.listdir(dataset):
            label = class_names_label[folder]

            # Iterate through each image in our folder
            for file in tqdm(os.listdir(os.path.join(dataset, folder))):

                # Get the path name of the image
                img_path = os.path.join(os.path.join(dataset, folder), file)
```

```
                # Open and resize the img
                image = cv2.imread(img_path)
                image = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
                image = cv2.resize(image, IMAGE_SIZE)

                # Append the image and its corresponding label to the output
                images.append(image)
                labels.append(label)

        images = np.array(images, dtype = 'float32')
        labels = np.array(labels, dtype = 'int32')

        output.append((images, labels))

    return output
```

In [34]:
```
(train_images, train_labels), (test_images, test_labels) = load_data()
```

```
Loading C:\Users\PC\OneDrive\Desktop\seg_train
100%|██████████████████████████████████████████████████████████████████████████████|
2191/2191 [00:30<00:00, 72.35it/s]
100%|██████████████████████████████████████████████████████████████████████████████|
2271/2271 [00:34<00:00, 65.40it/s]
100%|██████████████████████████████████████████████████████████████████████████████|
2404/2404 [00:37<00:00, 63.91it/s]
100%|██████████████████████████████████████████████████████████████████████████████|
2512/2512 [00:40<00:00, 62.17it/s]
100%|██████████████████████████████████████████████████████████████████████████████|
2274/2274 [00:34<00:00, 66.66it/s]
100%|██████████████████████████████████████████████████████████████████████████████|
2382/2382 [00:35<00:00, 67.28it/s]
Loading C:\Users\PC\OneDrive\Desktop\seg_test
100%|████████████████████████████████████████████████████████████████████████████████
| 437/437 [00:08<00:00, 50.08it/s]
100%|████████████████████████████████████████████████████████████████████████████████
| 474/474 [00:09<00:00, 52.23it/s]
100%|████████████████████████████████████████████████████████████████████████████████
| 553/553 [00:10<00:00, 52.17it/s]
100%|████████████████████████████████████████████████████████████████████████████████
| 525/525 [00:10<00:00, 52.11it/s]
100%|████████████████████████████████████████████████████████████████████████████████
| 510/510 [00:10<00:00, 50.94it/s]
100%|████████████████████████████████████████████████████████████████████████████████
| 501/501 [00:09<00:00, 51.30it/s]
```

In [35]:
```
n_train = train_labels.shape[0]
n_test = test_labels.shape[0]

print ("Number of training examples: {}".format(n_train))
print ("Number of testing examples: {}".format(n_test))
print ("Each image is of size: {}".format(IMAGE_SIZE))

print(train_labels.shape)
print(test_labels.shape)
```

```
Number of training examples: 14034
Number of testing examples: 3000
Each image is of size: (150, 150)
(14034,)
(3000,)
```

In [36]:
```
train_images = train_images / 255.0
test_images = test_images / 255.0
```

In [37]:
```
def display_random_image(class_names, images, labels):
    """
        Display a random image from the images array and its correspond label from the
    """

    index = np.random.randint(images.shape[0])
    plt.figure()
    plt.imshow(images[index])
    plt.xticks([])
    plt.yticks([])
    plt.grid(False)
    plt.title('Image #{} : '.format(index) + class_names[labels[index]])
    plt.show()
```

In [38]:
```
display_random_image(class_names, train_images, train_labels)
```

Image #805 : buildings

In [40]:
```
from tensorflow.keras.preprocessing.image import ImageDataGenerator

# Create an instance of the ImageDataGenerator
datagen = ImageDataGenerator(
    rotation_range=40,
    width_shift_range=0.2,
    height_shift_range=0.2,
```

```
    shear_range=0.2,
    zoom_range=0.2,
    horizontal_flip=True,
    fill_mode='nearest'
)

# Visualize a few augmented images
example_image = train_images[0]
example_image = example_image.reshape((1,) + example_image.shape)  # Reshape to (1, he

fig, ax = plt.subplots(1, 5, figsize=(15, 3))

for i, augmented_image in enumerate(datagen.flow(example_image, batch_size=1)):
    ax[i].imshow(augmented_image[0])
    ax[i].axis('off')

    if i == 4:
        break

plt.show()
```

In [41]:
```
# Create an instance of the ImageDataGenerator with augmentation parameters for traini
train_datagen = ImageDataGenerator(
    rotation_range=40,
    width_shift_range=0.2,
    height_shift_range=0.2,
    shear_range=0.2,
    zoom_range=0.2,
    horizontal_flip=True,
    fill_mode='nearest'
)

# Create an instance of the ImageDataGenerator without augmentation for validation
val_datagen = ImageDataGenerator()
```

In [42]:
```
# Define callbacks
early_stopping = tf.keras.callbacks.EarlyStopping(monitor='val_loss', patience=3, rest
model_checkpoint = tf.keras.callbacks.ModelCheckpoint('best_model.h5', save_best_only=
```

In [43]:
```
model = tf.keras.Sequential([
    tf.keras.layers.Conv2D(32, (3, 3), activation='relu', input_shape=(150, 150, 3)),
    tf.keras.layers.BatchNormalization(),
    tf.keras.layers.MaxPooling2D(2, 2),

    tf.keras.layers.Conv2D(64, (3, 3), activation='relu'),
    tf.keras.layers.BatchNormalization(),
    tf.keras.layers.MaxPooling2D(2, 2),

    tf.keras.layers.Conv2D(128, (3, 3), activation='relu'),
```

```
    tf.keras.layers.BatchNormalization(),
    tf.keras.layers.MaxPooling2D(2, 2),

    tf.keras.layers.Conv2D(256, (3, 3), activation='relu'),
    tf.keras.layers.BatchNormalization(),
    tf.keras.layers.MaxPooling2D(2, 2),

    tf.keras.layers.Conv2D(512, (3, 3), activation='relu'),
    tf.keras.layers.BatchNormalization(),
    tf.keras.layers.MaxPooling2D(2, 2),

    tf.keras.layers.Flatten(),

    tf.keras.layers.Dense(128, activation='relu'),
    tf.keras.layers.Dropout(0.5),

    tf.keras.layers.Dense(6, activation='softmax')
])
model.summary()
```

```
WARNING:tensorflow:From C:\Users\PC\AppData\Local\Programs\Python\Python310\lib\site-
packages\keras\src\backend.py:873: The name tf.get_default_graph is deprecated. Pleas
e use tf.compat.v1.get_default_graph instead.

WARNING:tensorflow:From C:\Users\PC\AppData\Local\Programs\Python\Python310\lib\site-
packages\keras\src\layers\pooling\max_pooling2d.py:161: The name tf.nn.max_pool is de
precated. Please use tf.nn.max_pool2d instead.

Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 148, 148, 32)      896

 batch_normalization (Batch  (None, 148, 148, 32)      128
 Normalization)

 max_pooling2d (MaxPooling2  (None, 74, 74, 32)        0
 D)

 conv2d_1 (Conv2D)           (None, 72, 72, 64)        18496

 batch_normalization_1 (Bat  (None, 72, 72, 64)        256
 chNormalization)

 max_pooling2d_1 (MaxPoolin  (None, 36, 36, 64)        0
 g2D)

 conv2d_2 (Conv2D)           (None, 34, 34, 128)       73856

 batch_normalization_2 (Bat  (None, 34, 34, 128)       512
 chNormalization)

 max_pooling2d_2 (MaxPoolin  (None, 17, 17, 128)       0
 g2D)

 conv2d_3 (Conv2D)           (None, 15, 15, 256)       295168

 batch_normalization_3 (Bat  (None, 15, 15, 256)       1024
 chNormalization)

 max_pooling2d_3 (MaxPoolin  (None, 7, 7, 256)         0
 g2D)

 conv2d_4 (Conv2D)           (None, 5, 5, 512)         1180160

 batch_normalization_4 (Bat  (None, 5, 5, 512)         2048
 chNormalization)

 max_pooling2d_4 (MaxPoolin  (None, 2, 2, 512)         0
 g2D)

 flatten (Flatten)           (None, 2048)              0

 dense (Dense)               (None, 128)               262272

 dropout (Dropout)           (None, 128)               0
```

```
 dense_1 (Dense)             (None, 6)                 774

=================================================================
Total params: 1835590 (7.00 MB)
Trainable params: 1833606 (6.99 MB)
Non-trainable params: 1984 (7.75 KB)
_________________________________________________________________
```

In [44]:
```
# Compile the model
model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

# Train the model with data augmentation for training data and without augmentation fo
history = model.fit(
    train_datagen.flow(train_images, train_labels, batch_size=32),
    steps_per_epoch=len(train_images) // 32,
    epochs=20,
    validation_data=val_datagen.flow(test_images, test_labels, batch_size=32),
    validation_steps=len(test_images) // 32,
    callbacks=[early_stopping, model_checkpoint]
)
```

```
WARNING:tensorflow:From C:\Users\PC\AppData\Local\Programs\Python\Python310\lib\site-
packages\keras\src\optimizers\__init__.py:309: The name tf.train.Optimizer is depreca
ted. Please use tf.compat.v1.train.Optimizer instead.

Epoch 1/20
WARNING:tensorflow:From C:\Users\PC\AppData\Local\Programs\Python\Python310\lib\site-
packages\keras\src\utils\tf_utils.py:492: The name tf.ragged.RaggedTensorValue is dep
recated. Please use tf.compat.v1.ragged.RaggedTensorValue instead.

WARNING:tensorflow:From C:\Users\PC\AppData\Local\Programs\Python\Python310\lib\site-
packages\keras\src\engine\base_layer_utils.py:384: The name tf.executing_eagerly_outs
ide_functions is deprecated. Please use tf.compat.v1.executing_eagerly_outside_functi
ons instead.

438/438 [==============================] - 426s 958ms/step - loss: 1.4518 - accuracy:
0.4814 - val_loss: 1.9771 - val_accuracy: 0.3353
C:\Users\PC\AppData\Local\Programs\Python\Python310\lib\site-packages\keras\src\engin
e\training.py:3103: UserWarning: You are saving your model as an HDF5 file via `mode
l.save()`. This file format is considered legacy. We recommend using instead the nati
ve Keras format, e.g. `model.save('my_model.keras')`.
  saving_api.save_model(
```

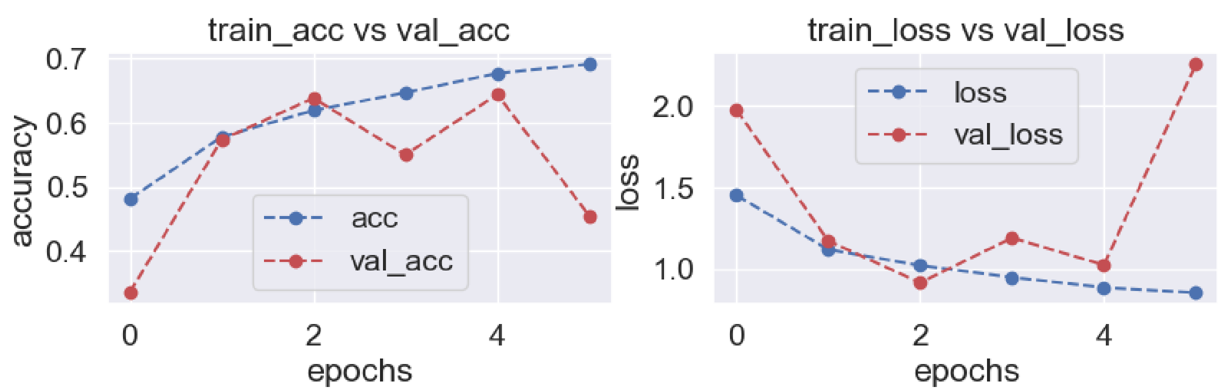
```
Epoch 2/20
438/438 [==============================] - 415s 947ms/step - loss: 1.1190 - accuracy:
0.5781 - val_loss: 1.1724 - val_accuracy: 0.5736
Epoch 3/20
438/438 [==============================] - 407s 928ms/step - loss: 1.0214 - accuracy:
0.6193 - val_loss: 0.9157 - val_accuracy: 0.6384
Epoch 4/20
438/438 [==============================] - 413s 942ms/step - loss: 0.9486 - accuracy:
0.6470 - val_loss: 1.1902 - val_accuracy: 0.5501
Epoch 5/20
438/438 [==============================] - 381s 869ms/step - loss: 0.8862 - accuracy:
0.6770 - val_loss: 1.0246 - val_accuracy: 0.6442
Epoch 6/20
438/438 [==============================] - 384s 876ms/step - loss: 0.8543 - accuracy:
0.6913 - val_loss: 2.2552 - val_accuracy: 0.4550
```

In [45]:

```python
def plot_accuracy_loss(history):
    """
        Plot the accuracy and the loss during the training of the nn.
    """
    fig = plt.figure(figsize=(10,5))

    # Plot accuracy
    plt.subplot(221)
    plt.plot(history.history['accuracy'],'bo--', label = "acc")
    plt.plot(history.history['val_accuracy'], 'ro--', label = "val_acc")
    plt.title("train_acc vs val_acc")
    plt.ylabel("accuracy")
    plt.xlabel("epochs")
    plt.legend()

    # Plot loss function
    plt.subplot(222)
    plt.plot(history.history['loss'],'bo--', label = "loss")
    plt.plot(history.history['val_loss'], 'ro--', label = "val_loss")
    plt.title("train_loss vs val_loss")
    plt.ylabel("loss")
    plt.xlabel("epochs")

    plt.legend()
    plt.show()
```

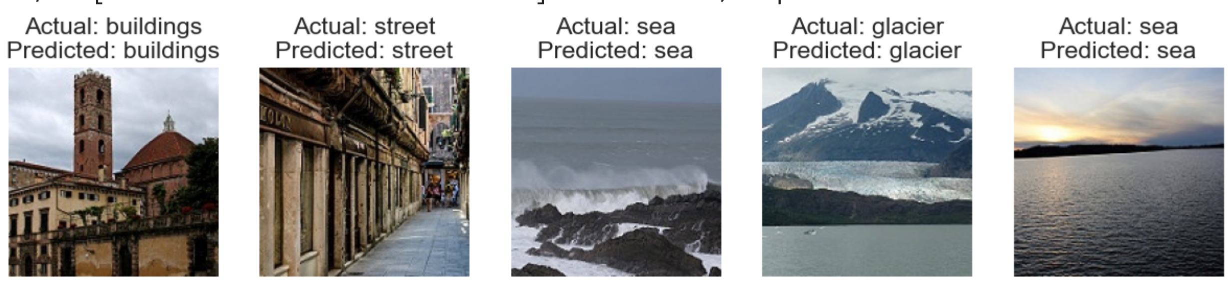
In [46]:

```python
plot_accuracy_loss(history)
```

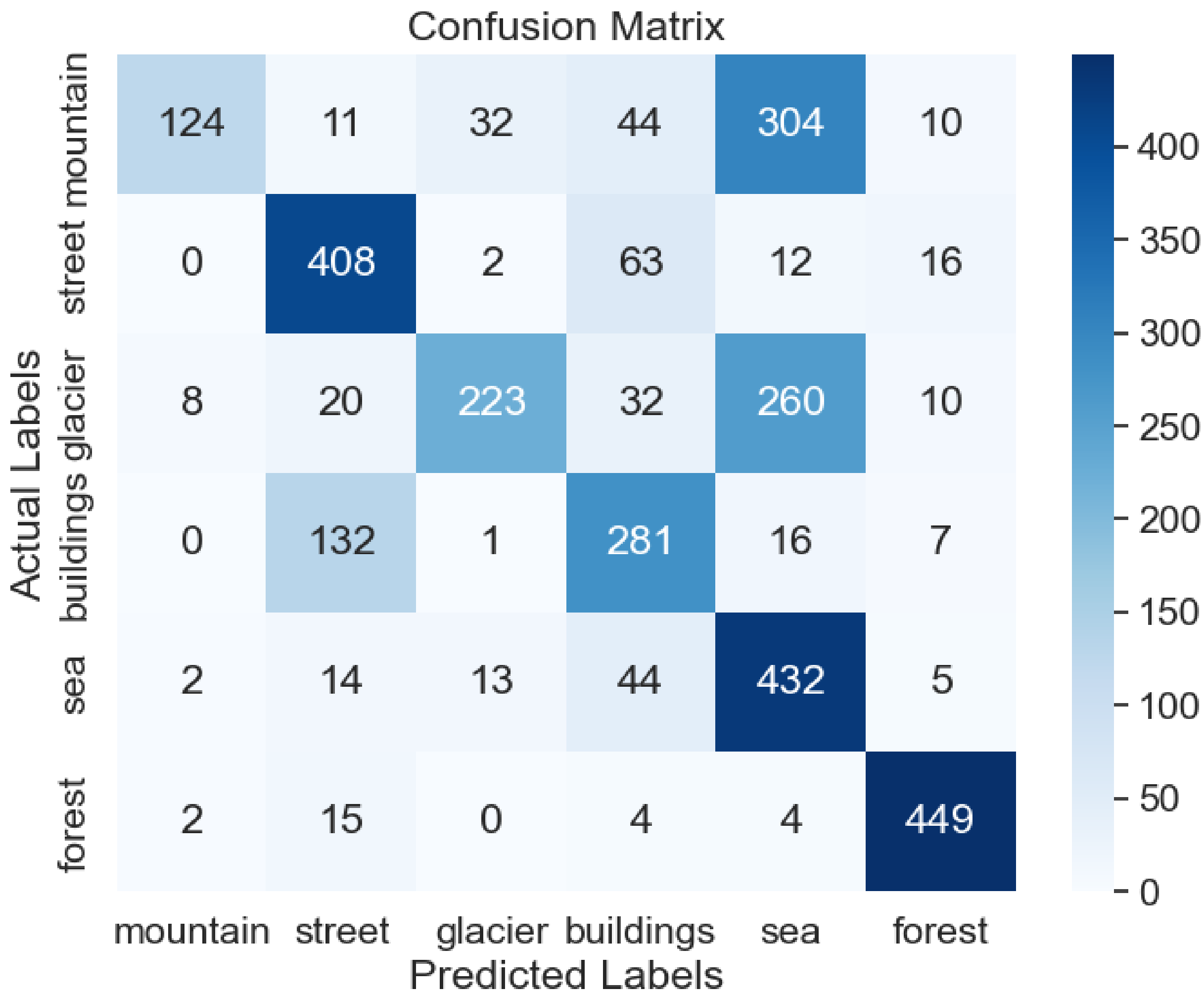


In [48]:
```
# Evaluate the model on the test set
test_loss, test_accuracy = model.evaluate(test_images, test_labels, verbose=2)
print("\nTest Accuracy:", test_accuracy)

# Make predictions on the test set
predictions = model.predict(test_images)
predicted_labels = np.argmax(predictions, axis=1)

# Display random images with actual and predicted labels
def display_random_images(images, actual_labels, predicted_labels, class_names, num_im
    indices = np.random.choice(len(images), num_images, replace=False)

    plt.figure(figsize=(15, 5))
    for i, index in enumerate(indices, 1):
        plt.subplot(1, num_images, i)
        plt.imshow(images[index])
        plt.title(f"Actual: {class_names[actual_labels[index]]}\nPredicted: {class_nam
        plt.axis('off')

    plt.show()

# Display random images
display_random_images(test_images, test_labels, predicted_labels, class_names)
```

```
94/94 - 19s - loss: 0.9134 - accuracy: 0.6390 - 19s/epoch - 206ms/step

Test Accuracy: 0.6389999985694885
94/94 [==============================] - 20s 212ms/step
```



In [49]:
```
from sklearn.metrics import confusion_matrix
import seaborn as sns

# Generate the confusion matrix
conf_matrix = confusion_matrix(test_labels, predicted_labels)

# Plot the confusion matrix
plt.figure(figsize=(8, 6))
sns.heatmap(conf_matrix, annot=True, fmt='d', cmap='Blues', xticklabels=class_names, y
plt.title('Confusion Matrix')
plt.xlabel('Predicted Labels')
plt.ylabel('Actual Labels')
plt.show()
```



In [50]:

```
# Load the pre-trained InceptionV3 model without the top layers
base_model = tf.keras.applications.InceptionV3(weights='imagenet', include_top=False,

# Choose the number of layers to freeze
num_layers_to_freeze = 20

# Freeze only the first num_layers_to_freeze layers
for layer in base_model.layers[:num_layers_to_freeze]:
    layer.trainable = False
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/in
ception_v3/inception_v3_weights_tf_dim_ordering_tf_kernels_notop.h5
87910968/87910968 [==============================] - 37s 0us/step
```

In [51]:

```
# Import models module from Keras
from tensorflow.keras import models
# Import necessary layers module from Keras
from tensorflow.keras import layers

# Create a new model by adding custom layers on top of VGG16
model = models.Sequential([
    base_model,
    layers.Flatten(),
    layers.Dense(256, activation='relu'),
    layers.Dropout(0.5),
    layers.Dense(128, activation='relu'),
```

```
    layers.Dropout(0.5),
    layers.Dense(nb_classes, activation='softmax')
])
```

In [52]:
```
# Compile the model
model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])
```

In [53]:
```
# Create an instance of the ImageDataGenerator with augmentation parameters for traini
train_datagen = ImageDataGenerator(
    rotation_range=40,
    width_shift_range=0.2,
    height_shift_range=0.2,
    shear_range=0.2,
    zoom_range=0.2,
    horizontal_flip=True,
    fill_mode='nearest'
)

# Create an instance of the ImageDataGenerator without augmentation for validation
val_datagen = ImageDataGenerator()
```

In [54]:
```
# Define callbacks
early_stopping = tf.keras.callbacks.EarlyStopping(monitor='val_loss', patience=3, rest
model_checkpoint = tf.keras.callbacks.ModelCheckpoint('best_model_vgg16.h5', save_best
```

In [55]:
```
# Train the model with data augmentation for training data and without augmentation fo
history = model.fit(
    train_datagen.flow(train_images, train_labels, batch_size=32),
    steps_per_epoch=len(train_images) // 32,
    epochs=20,
    validation_data=val_datagen.flow(test_images, test_labels, batch_size=32),
    validation_steps=len(test_images) // 32,
    callbacks=[early_stopping, model_checkpoint]
)
```

```
Epoch 1/20
438/438 [==============================] - ETA: 0s - loss: 1.4865 - accuracy: 0.3809
```

```
C:\Users\PC\AppData\Local\Programs\Python\Python310\lib\site-packages\keras\src\engin
e\training.py:3103: UserWarning: You are saving your model as an HDF5 file via `mode
l.save()`. This file format is considered legacy. We recommend using instead the nati
ve Keras format, e.g. `model.save('my_model.keras')`.
  saving_api.save_model(
```

```
438/438 [==============================] - 805s 2s/step - loss: 1.4865 - accuracy: 0.
3809 - val_loss: 1.0766 - val_accuracy: 0.4929
Epoch 2/20
438/438 [==============================] - 856s 2s/step - loss: 1.0276 - accuracy: 0.
5681 - val_loss: 0.8652 - val_accuracy: 0.6418
Epoch 3/20
438/438 [==============================] - 743s 2s/step - loss: 0.9421 - accuracy: 0.
6298 - val_loss: 0.9575 - val_accuracy: 0.6183
Epoch 4/20
438/438 [==============================] - 759s 2s/step - loss: 0.8713 - accuracy: 0.
6603 - val_loss: 1.4192 - val_accuracy: 0.4677
Epoch 5/20
438/438 [==============================] - 822s 2s/step - loss: 0.9250 - accuracy: 0.
6607 - val_loss: 0.7869 - val_accuracy: 0.6962
Epoch 6/20
438/438 [==============================] - 820s 2s/step - loss: 0.7979 - accuracy: 0.
7418 - val_loss: 0.7433 - val_accuracy: 0.7806
Epoch 7/20
438/438 [==============================] - 817s 2s/step - loss: 0.7492 - accuracy: 0.
7463 - val_loss: 0.6401 - val_accuracy: 0.7409
Epoch 8/20
438/438 [==============================] - 941s 2s/step - loss: 0.7010 - accuracy: 0.
7608 - val_loss: 0.5687 - val_accuracy: 0.8017
Epoch 9/20
438/438 [==============================] - 763s 2s/step - loss: 0.7042 - accuracy: 0.
7594 - val_loss: 1.1795 - val_accuracy: 0.6109
Epoch 10/20
438/438 [==============================] - 765s 2s/step - loss: 0.6153 - accuracy: 0.
7930 - val_loss: 0.4036 - val_accuracy: 0.8606
Epoch 11/20
438/438 [==============================] - 1200s 3s/step - loss: 0.5841 - accuracy:
0.8034 - val_loss: 0.6281 - val_accuracy: 0.7860
Epoch 12/20
438/438 [==============================] - 763s 2s/step - loss: 0.6277 - accuracy: 0.
8074 - val_loss: 0.5683 - val_accuracy: 0.7876
Epoch 13/20
438/438 [==============================] - 769s 2s/step - loss: 0.5920 - accuracy: 0.
8049 - val_loss: 0.4336 - val_accuracy: 0.8501
```

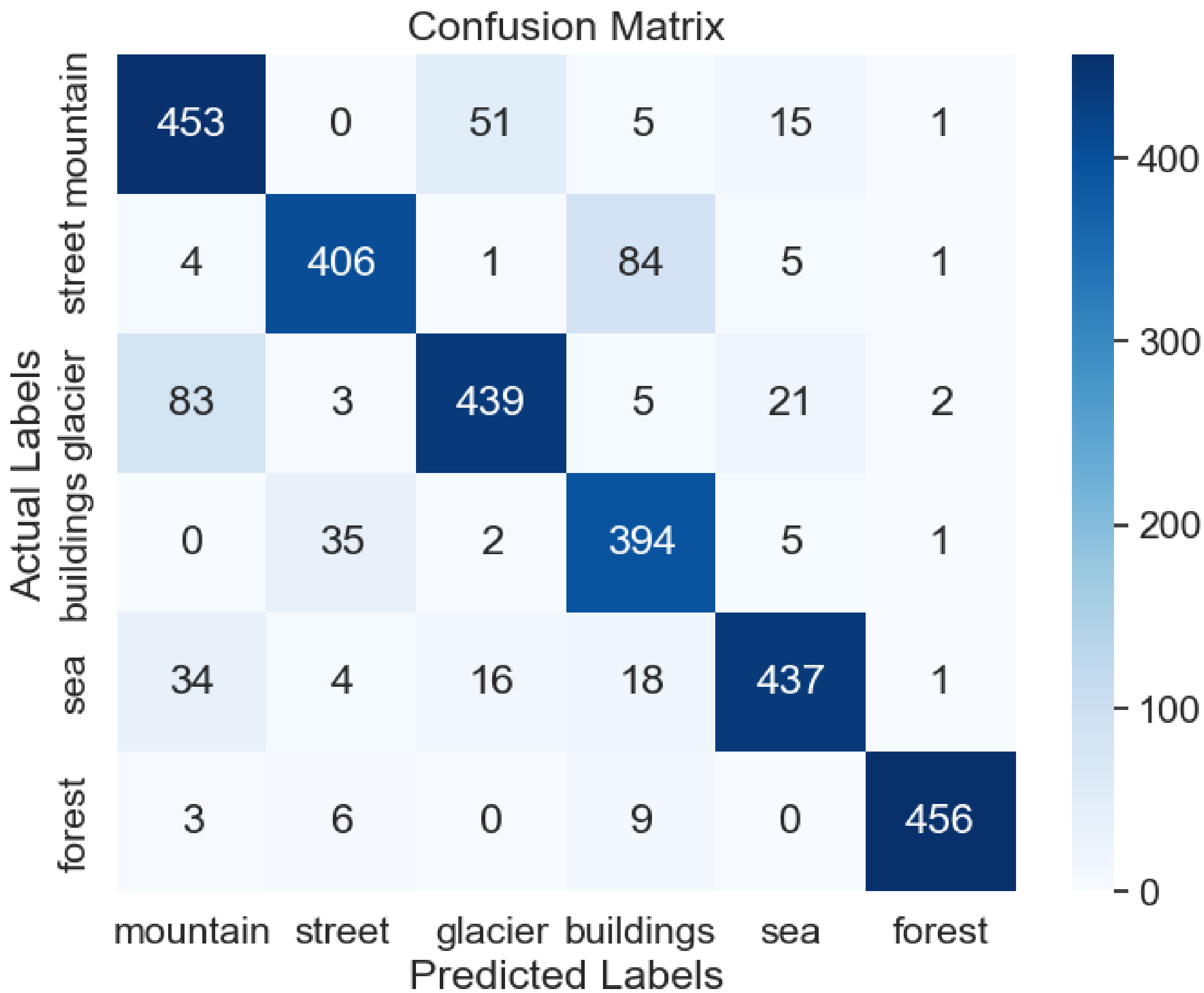
In [56]:

```
# Evaluate the model on the test set
test_loss, test_accuracy = model.evaluate(test_images, test_labels, verbose=2)
print("\nTest Accuracy:", test_accuracy)

# Make predictions on the test set
predictions = model.predict(test_images)
predicted_labels = np.argmax(predictions, axis=1)

# Display random images with actual and predicted labels
def display_random_images(images, actual_labels, predicted_labels, class_names, num_im
    indices = np.random.choice(len(images), num_images, replace=False)

    plt.figure(figsize=(15, 5))
    for i, index in enumerate(indices, 1):
        plt.subplot(1, num_images, i)
        plt.imshow(images[index])
        plt.title(f"Actual: {class_names[actual_labels[index]]}\nPredicted: {class_nam
        plt.axis('off')
```

```
    plt.show()

# Display random images
display_random_images(test_images, test_labels, predicted_labels, class_names)
```

```
94/94 - 48s - loss: 0.4013 - accuracy: 0.8617 - 48s/epoch - 514ms/step

Test Accuracy: 0.8616666793823242
94/94 [==============================] - 39s 395ms/step
```

In [57]:
```
from sklearn.metrics import confusion_matrix
import seaborn as sns

# Generate the confusion matrix
conf_matrix = confusion_matrix(test_labels, predicted_labels)

# Plot the confusion matrix
plt.figure(figsize=(8, 6))
sns.heatmap(conf_matrix, annot=True, fmt='d', cmap='Blues', xticklabels=class_names, y
plt.title('Confusion Matrix')
plt.xlabel('Predicted Labels')
plt.ylabel('Actual Labels')
plt.show()
```


Confusion Matrix
Actual Labels
mountain
street
glacier
buildings
sea
forest
453 0 51 5 15 1
4 406 1 84 5 1
83 3 439 5 21 2
0 35 2 394 5 1
34 4 16 18 437 1
3 6 0 9 0 456
mountain street glacier buildings sea forest
Predicted Labels
400
300
200
100
0

```
In [ ]:
```