Design and Production of an Atlas for Diplomacy in Zimbabwe and The Southern African Development Community

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Abstract

An atlas of Zimbabwe and the Southern African Development Community was designed and produced for use by American diplomats in Zimbabwe. Two copies of the bound atlas are used by the Embassy of the United States of America (U.S. Embassy) and the Mission of the U.S. Agency for International Development (USAID) in Harare, Zimbabwe, to orient visitors and discuss matters of diplomacy and development in Zimbabwe and the Southern African Development Community. The atlas contains maps derived from satellite images showing features of the physical geography of Southern Africa and Zimbabwe and plastic overlays showing rivers and lakes and manmade features, such as major roads, railroads, and cities. The atlas is an important tool that American diplomats can use to orient participants in discussions of the environment and to develop agreements for management of the environment in Zimbabwe and Southern Africa.

Introduction

Diplomats and others making policy and managing economic development are concerned with physical, political, economic, and cultural aspects of the human environment. They work within the context of regional, transnational, national, and subnational boundaries that have been imposed upon the Earth's surface as a spatial framework in which to manage the environment and human activities.

The Government of the United States of America conducts diplomatic affairs in Zimbabwe and other states within the Southern African Development Community (SADC). In addition, the Government of the United States, through the U.S. Agency for International Development (USAID), influences the condition of the human environment by providing economic development assistance to Zimbabwe and other states within the SADC. In 1995, the USAID Mission to Zimbabwe (USAID/Zimbabwe) saw a need to better understand the spatial relationships among physical features, political boundaries, land use, and infrastructure in Zimbabwe and the part of southern Africa that falls within the boundaries of SADC. In August 1995, USAID/Zimbabwe requested that the USGS prepare a book of satellite image maps and other maps with line work to provide geospatial orientation for discussions concerning Zimbabwe and the other 11 continental member states of SADC.

Zimbabwe is one of 12 members of SADC, a group of states in southern Africa promoting political stability and economic growth in the region. Eleven member states of SADC, namely Angola, Botswana, Lesotho, Malawi, Mozambique Namibia, the Republic of South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe, are located on the continent of Africa. The twelfth member of SADC, Mauritius, is located approximately 2,000 kilometers east of the coast of Mozambique. The SADC countries account for 40 percent of Africa's human population, and approximately 80 percent of the continent's exports, imports, and total Gross National Product (UNEP, 1997). Moreover, the human population of the SADC countries, which was 130 million in mid-1993 (IBRD, 1995), is expected to double by the year 2020 (UNEP, 1997). With a doubling of the human population in the region, human demands on the environment and the need to properly manage that environment will increase greatly. In southern Africa, human competition with natural flora and other fauna for habitat and natural resources will continue to increase dramatically during the next two decades. Maps are essential to identify, understand, and manage the interactions of humans with the plants, animals, and abiotic components of the

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environment in this and other regions of the world.

Materials and Methods

Spatial Data Models

Two fundamentally different models are commonly used to represent the spatial component of geographic information, namely the raster and vector models. The raster model divides any two-dimensional space into regularly subdivided cells, usually square in shape, with the location of geographic objects or conditions defined by the row and column position occupied by each cell (Aronoff, 1993). Satellite images, recorded as raster data, are acquired by electro-optical sensors that record the intensity of electromagnetic radiation striking the sensor. An image analysis system of computer hardware and software is used; it shows many picture elements, or pixels, in rows and columns that are consistent with the raster model. An image analysis system can process the data to highlight certain aspects of the land surface that were detected by the sensor onboard the satellite (Aronoff, 1993). The satellite image maps of this atlas are produced principally from raster data, with some vector data.

The other model used to represent spatial components of geographic information is the vector model. Features of the three-dimensional world are depicted using points, lines, and polygons, which are described by a coordinate reference system that is stored in digital files. A geographic information system (GIS) composed of computer hardware and software is used for manipulating the data to do spatial analysis and create maps. Each point, line, and polygon on the map has a unique set of coordinates, and by using a GIS, it is possible to compose or modify a map. Spatial data can be converted from vector to raster format and from raster to vector format to do spatial analysis or compose maps using data compatible in one or the other of the two formats. If vector and raster data are used in the same map, the data of each model must be registered to the data of the other model so that common features coincide and features that do not occupy the same space in the three-dimensional world will not appear to do so on the two-dimensional map. (DMA, 1992). The maps of this atlas, which show boundaries imposed by humans, hydrographic features, transportation features, and lines of latitude and longitude, were composed solely from vector data.

Design of the Atlas

The atlas was designed to meet the needs of diplomats of the U.S. Embassy and the USAID Mission in Zimbabwe by providing spatial orientation for discussions concerning both Zimbabwe and the SADC. Maps were needed to depict both the physical geography and manmade features such as political boundaries, locations of cities, and transportation infrastructure. The maps were intended for discussions of a strategic nature, rather than for operational purposes, which would require more detailed maps.

To determine the scale at which the satellite image base maps would be produced, USGS cartographers printed, a raster satellite image of Zimbabwe at several different scales, ranging from 1:6,000,000 to l:1,000,000, and decided that the best scale for the atlas would be approximately 1:2,500,000. At this resolution, the shapes of square pixels are nearly indistinguishable and details of features are easily visible. The satellite image base map of the SADC would be printed at approximately 1:6,000,000 to conform to the size of the Zimbabwe base maps. All transparent overlays and the base maps were to be registered to one another in such a way that each base map and its accompanying plastic overlays of other spatial information, such as major hydrographic features, transportation networks, or lines of latitude and longitude, would appear to be one map, but the base map could also be viewed separately. For additional clarity and ease of viewing, the information from all the overlays was also to be plotted on white paper, allowing features of the plastic overlays to be viewed with either a satellite image or the color white as background. A detailed design, including layout of the text and location of all photographically produced maps, transparent overlays, and maps plotted on paper, was developed on sheets of 21.59- by 27.94-cm paper, in a looseleaf binder. During production of the atlas, as decisions to change production methods were made, new pages with design changes replaced obsolete elements of the design.

Raster Data - SADC

To create a mosaic satellite image map of SADC countries, advanced very high resolution radiometer (AVHRR) scenes from images acquired by sensors aboard the National Oceanic and Atmospheric Administration satellite No. 11 (NOAA-11) during May 1992, the end of the rainy season in most of southern Africa. From 50 available scenes, approximately 30 were selected to compose a mosaic of the 11- country SADC region. Then, an image analysis system that can process AVHRR data produced a nearly cloudless, composite satellite image of the region.

The data were geometrically rectified, using an AVHRR satellite model, to correct spatial distortions of the mosaicked AVHRR data. The corrections were accomplished by using the hydrologic features, coastlines, and lakes from the Digital Chart of the World (DCW) (DMA, 1992). These features of the DCW were converted from vector to raster format, mapped to the satellite projection, and matched to the AVHRR images using binary edge-correlation techniques. The image was then precision-corrected to the Interrupted Goode Homolosine projection. This projection is an equal-area projection that facilitates spatial analysis and divides the world into 12 regions that can be mosaicked into a global map (Steinwand, l994).

Elevation data from the Global 30-Arc-Second Elevation (GTOPO 30) date set, produced and available to the public at the USGS EROS Data Center, were added to enhance the mosaicked, geometrically rectified image by creating a shaded-terrain color image. AVHRR data of channel 1 (0.58-0.68 μm) and channel 2 (0.72 - 1.1 μm) were combined in red, green, blue (R, G, B) order in the sequence of [2, 1, 1] to produce a false-color-infrared image that showed the distribution of healthy growing vegetation. In this rendition, vegetation appears as shades of red, water ranges from blue to black, naturally light-toned areas appear tan to white, clouds are white, and shadows are dark.

Raster Data - Zimbabwe

Knowing that Zimbabwe experiences annual wet and dry seasons and droughts that can decrease crop production to the point where food aid is needed to prevent starvation, American diplomats in Harare requested maps that would show the effects of different amounts of rainfall on the distribution of vegetation in Zimbabwe. The following criteria were used to select AVHRR scenes that would show the vegetative cover of Zimbabwe during the rainy season, at the end of the rainy season, during the dry season, during an exceptionally wet year, and during a drought year: (1) The area covered by the AVHRR scene was to include a point near the center of Zimbabwe; *i.e.*, 19ºS latitude, 29ºE longitude; (2) That point was to be near the central line of the AVHRR scene, running in an approximately north-to-south direction; and (3) the cloud cover in the area occupied by Zimbabwe was to be estimated, by visual inspection, as less than 1 percent. Of approximately 1500 AVHRR scenes meeting criterion 1, only 41 scenes met criteria 2 and 3. From those 41 scenes, 4 were selected to depict differences in vegetative land cover associated with the specified rainfall conditions. Digital data files for the four AVHRR scenes were obtained from the public archive of satellite images located at the USGS EROS Data Center.

The four AVHRR Zimbabwe satellite images were geometrically corrected using the AVHRR satellite model software to systematically register the images to a Transverse Mercator (TM) projection defined by a central meridian of 29ºE and latitude of origin at 19.5ºS. The images were precision corrected using the hydrological features of the DCW as the control base. The Zimbabwe images were further enhanced by adding the elevation data to produce shaded-terrain color images. A part of the same elevation data set described for the SADC image was used. The AVHRR data were processed in the same manner as described for the SADC satellite image map to show the distribution of healthy, growing vegetation. However, the relative color balance of each of the four satellite image maps of Zimbabwe was adjusted both to enhance the inherent information content of each image and to equalize the scene-to-scene color range as much as possible.

Vector Data

After the raster AVHRR data of the SADC region and Zimbabwe had been processed, several other steps were necessary to complete the satellite image maps. ARC/INFO® software was used to extract national boundaries from the DCW, and the boundary data were then reprojected from geographic to the proper projections (TM for the Zimbabwe map and Interrupted Goode Homolosine for the SADC map). The data were then converted to a PostScript™ file and ingested into Adobe Illustrator™, where image information, titles, and scale bars were added. Adobe Photoshop™ was used to convert the collar of the map from vector format into a raw binary file, which was subsequently converted into a raster image file using Land Analysis System software and then embedded into the satellite image data. The vector data were converted to raster format to produce color positive film transparencies of the satellite image maps.

All other vector data shown in the atlas were plotted as vector data on either clear Mylar™ plastic or paper. Data plotted on plastic were used as overlays on the satellite image base maps to provide geographic references of latitude and longitude and to show how human activity has imposed administrative and other boundaries and transportation infrastructure on the landscape. Data plotted on paper contained all the data layers of the plastic overlays combined to show interrelationships of the physical features and the features of the landscape resulting from political and economic activities.

All the vector material of the overlays was derived in the same manner as the vector data for the base maps. Hydrography data were extracted from the DCW, as were populated places and political boundaries. Because a generalized network was desired for roads and railroads, these data were extracted from the ARCWORLD™ 1:3,000,000M data set (Sweitzer, 1996). These road and railroad data were reprojected in ARC/INFO® and converted to Adobe Illustrator™ format. Labeling, titles, and legends were then added to complete the composition of the overlays. Line work and attribution for the land tenure and natural region overlays were obtained from work done in Zimbabwe. The data were combined with the legend, and titles and polygon color fill were added to make the overlays. The vector data were input to a Versatec 8936L-4R plotter, and plastic and paper maps were produced measuring 66- by 48.30-cm.

Photographic Processes

After the digital files for the satellite image base maps were completed, the data were transferred to a laser beam film-recorder instrument, MacDonald Dettwiler Associates, Inc., Color Film Image Recorder (“ColorFIRE”), and a 25- by 25-cm positive transparency was produced for each file. Then the following procedure was carried out in the darkroom to determine the enlargement needed to print each satellite image. An appropriate 68.6- by 49.5-cm plastic overlay, with plotted geospatial data to be bound with the image in the atlas, was taped onto an easel, and the ColorFIRE positive transparency of the satellite image base map was placed in the carrier of the enlarger. There are small distortions of linework caused by mechanical plotting on plastic sheets, and there are small distortions in features of the satellite image base maps caused by optical and other factors in the photographic enlargement process. Therefore, to print each satellite image base map, the cartographer projected the image of the landmass onto the line work of the plastic overlay on the easel and adjusted the enlarger, so that the satellite image map was sized to the necessary scale to correctly align the overlay and the base map. Then, the satellite image map was printed using a Durst 2506 enlarger. This print was processed using a Hope R-3 color processor and returned to the darkroom to verify that the line work of the plastic overlay and the features of the satellite image map were closely aligned. After each print had been properly enlarged, it was processed using a Hope R-3 color processor and trimmed.

Assembly of the Atlas

All photographically produced maps and maps plotted on paper were laminated using a General Binding Corporation Model No. 425LM-1 laminator. The lamination was trimmed to leave a 6mm overhang on three sides of the map and a 13-mm overhang on the left side of the map for binding. Binding was done by using spacers between sheets and sewing the transparent Mylar™ sheets and lamination before gluing the bound sheets to the cover. The dimensions of the atlas cover are 50.8 cm high by 69.8 cm wide by 1.8 cm thick, and the hard cover is Grade F Buckram 990 (black) with lettering stamped in a contrasting color.

Results

The atlas is entitled “Atlas of Zimbabwe and the Southern African Development Community” and is composed of five sections containing groups of maps. At the beginning of each section are an index and brief descriptions of the maps within that section.

Section I, “Southern African Development Community,” includes two copies of a satellite image base map (Fig. 1), each of which has a transparent overlay one showing major

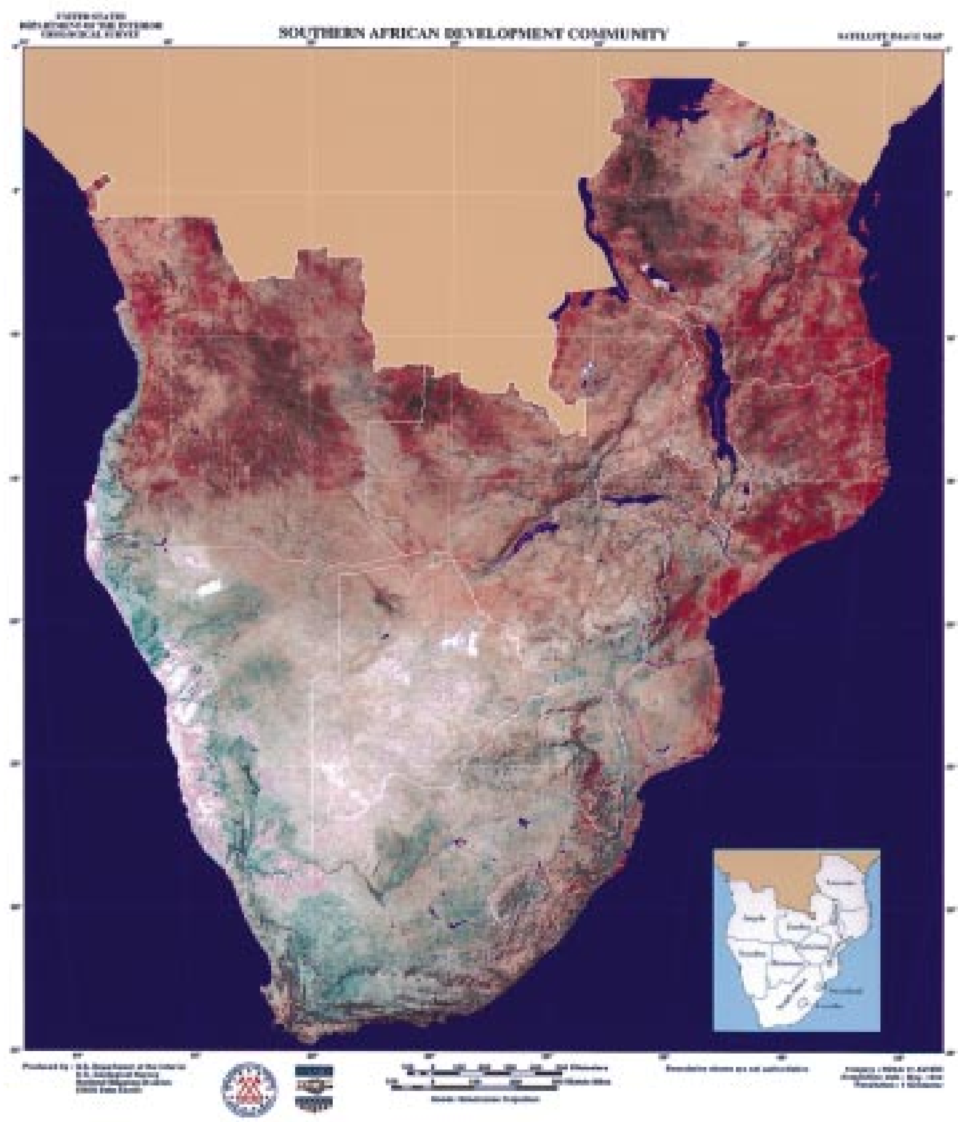

Figure 1 Southern African Development Community May 1992 satellite image map.

cities, roads, and railroads, and the other showing rivers and lakes. The base map indicates the presence of vegetation by red and indicates relief by simulated shadows. The boundaries and names of the SADC countries are indicated on the base map.

Section II, “Zimbabwe Land Tenure, Natural Regions, and Provincial Boundaries,” includes two copies of a satellite image map bounded by a rectangle formed by 24ºE and 37ºE longitude and 15ºS and 23ºS latitude. An AVHRR image acquired July 6, 1990, was selected as the base map to show a maximum amount of cloudless landscape and as much vegetation as possible for both Zimbabwe and the surrounding countries (Fig. 3b). Transparent overlays (not shown) include (1) land tenure and (2) natural regions and provincial boundaries. The land tenure categories included are communal lands, resettlement areas, large-scale and small-scale commercial farming areas, cities and municipalities national parks, safari and forest areas, recreational areas, and lakes. Natural regions 1 through 5 are ecological regions categorized principally by rainfall and temperature, with Region I (annual rainfall > 1000 mm) being in the high mountains along the border with Mozambique, Regions IIa and IIb (annual rainfall around 800 mm) in Mashonalands West, Central, and East, Region III (annual rainfall between that of Regions II and IV) principally in the Midlands, Region IV (rainfall ˜500 mm per annum) mainly in Matabeleland and northern parts of Matabeleland South and Masvingo, and Region V (annual rainfall < 200 mm) mainly in southern Matabeleland South and Masvingo and along the border of Zimbabwe with Zambia.

Section III, “Zimbabwe Major Cities, Roads, Railways, Rivers, Lakes, and Grid,” includes the same satellite image base map used in Section II and two transparent overlays, one showing mayor cities, roads, and railroads and the other showing rivers, lakes, and a grid of lines of latitude and longitude.

Section IV is composed of four satellite image maps of Zimbabwe showing topographical features, vegetation, and parts of surrounding countries. Each map is bounded by a rectangle formed by 24ºE and 37ºE longitude and 15ºS and 23ºS latitude. The first map shows vegetative cover on November 4, 1986, during the growing season in a wet year (Fig 3a). The second map shows vegetative cover on July 6, 1990, during the dry season in a dry year (Fig 3b). The third (Fig. 3c) and fourth (Fig. 3d) maps show vegetative cover in Zimbabwe and surrounding areas at the end of the growing season (April 16, 1995) and in the dry season (July 9, 1995) of a drought year.

Section V, “SADC and Zimbabwe Data from Sections I - III, Colored Ink on Paper,” presents information that is also printed on the transparencies in Sections I - III, but in Section V the thematic information is printed on white paper, rather than on transparent plastic, to highlight the information without the background of the satellite-image maps. Four maps show (1) SADC major cities, roads, rivers, lakes, and grid (Fig. 2), (2) land tenure in Zimbabwe, (3) natural regions and provincial boundaries of Zimbabwe, and (4) mayor cities, roads, railroads, rivers, lakes, and grid for Zimbabwe (Fig. 4).

Discussion

The rainy season in most of southern Africa normally extends from October through April. The satellite image map of the SADC (Fig. 1), which is a mosaic of satellite images acquired on several dates within the month of May 1992, depicts the distribution of vegetation in the region at the end of the rainy season in 1992. In May 1992, relatively little vegetation was detectable by AVHRR satellite images in most of Botswana and much of Namibia and the Republic of South Africa. Most of the road and rail infrastructure in the region is located in the Republic of South Africa. Hydrologic features include major lakes in the northeast part of the region; that is, Lake Victoria, Lake Tanganyika, Lake Nyasa (or Malawi), and two large reservoirs, Lake Cabora Bassa and Lake Kariba, on the Zambezi River. Notably high and low elevations are Mt. Kilimanjaro in Tanzania, the Makgadikgadi Pans in Botswana, and the Etosha Pan in Namibia. Many of the streams in the desert areas of Botswana and Namibia are intermittent, whereas most of the major streams and rivers throughout the rest of the SADC countries flow throughout the year.

In Zimbabwe, national parks and safari and forest areas tend to be located contiguous to Zimbabwe’s national boundaries, although there are some protected areas that do not have boundaries in common with the country’s national boundaries. Communal lands, resettlement areas, and small- and large-scale farming areas make up large parts of the country. Communal lands are large tracts owned by the government of Zimbabwe, which grants right-of-use to villages; resettlement areas are tracts of land occupied by settlers, who must annually renew their permits of occupation granted by the government of Zimbabwe.

The satellite image for the base map (Fig. 3b) of Zimbabwe was acquired on July 6, 1990, which is in the dry season. The base map of Zimbabwe shows large parts of the country colored white or blue, indicating little vegetation. Red areas in the southeastern area of Zimbabwe indicate the presence of irrigated crops. From north to south in Mozambique, the Zambezi, Save, and Limpopo Rivers are seen to flow from Zimbabwe to the Indian Ocean (Figs. 2, 3a, 3b, 3c, 3d, and 4).

The plastic overlay of natural regions and provinces of Zimbabwe (not shown) shows the spatial relationships between the provinces and natural regions and their relationships to the topography and vegetation of Zimbabwe on July 6, 1990. On the satellite image base maps, a prominent geological feature, the Great Dike, is clearly visible running north and south, and mountain ranges are visible throughout the country (Figs. 3a, b, c, and d). Large dunes, associated with the Kalahari Desert, are visible in the western part of Zimbabwe, just north of its southern border and to the south of the western tip of Lake Kariba.

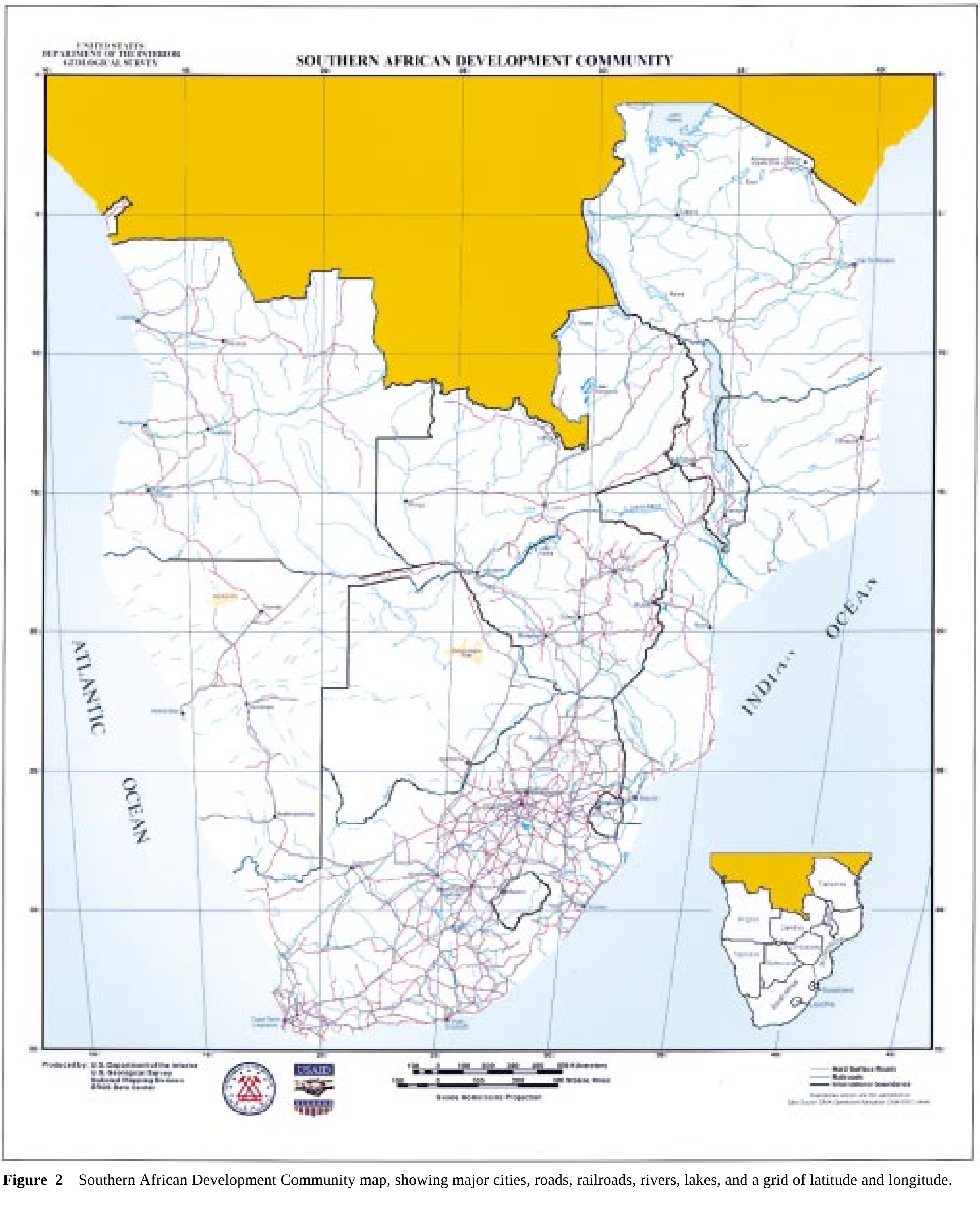

Figure 2 Southern African Development Community map, showing major cities, roads, railroads, rivers, lakes, and a grid of latitude and longitude.

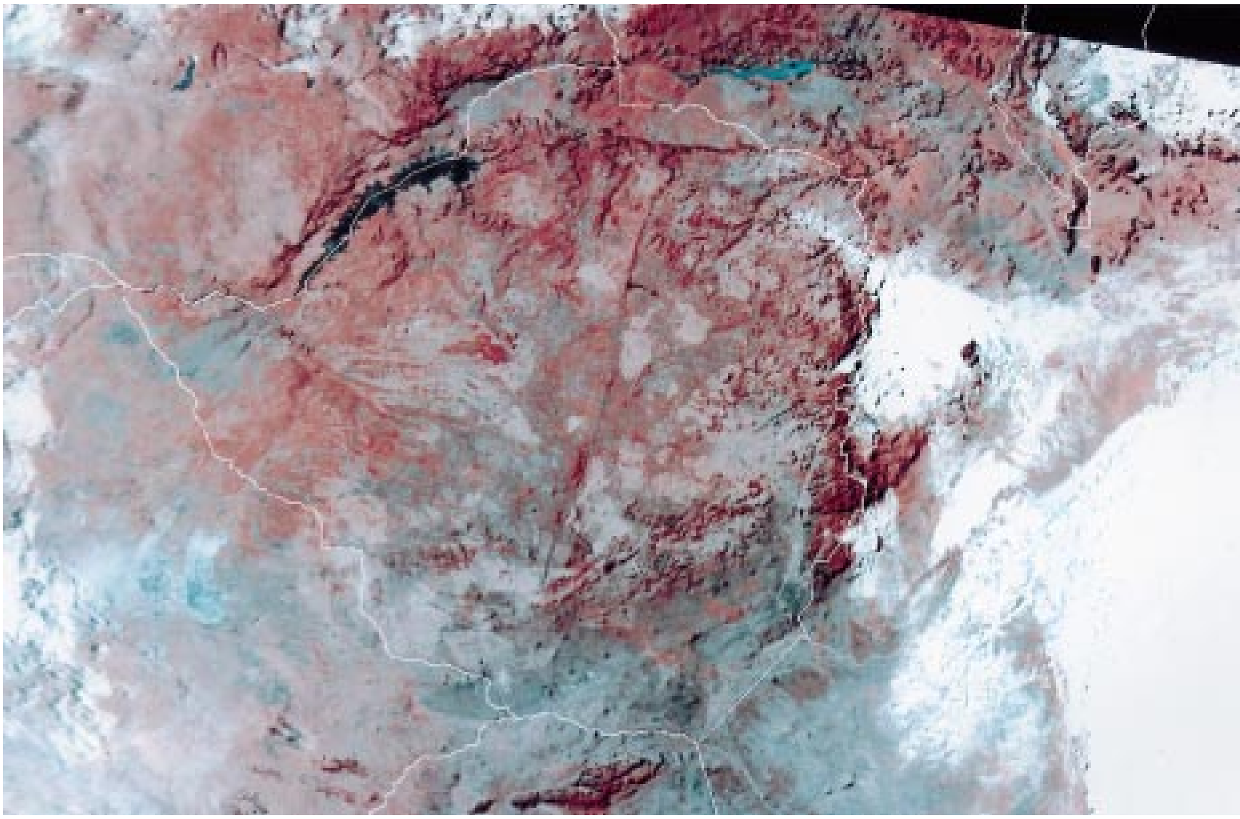

Figure 3a Zimbabwe November 4, 1986 satellite image map.

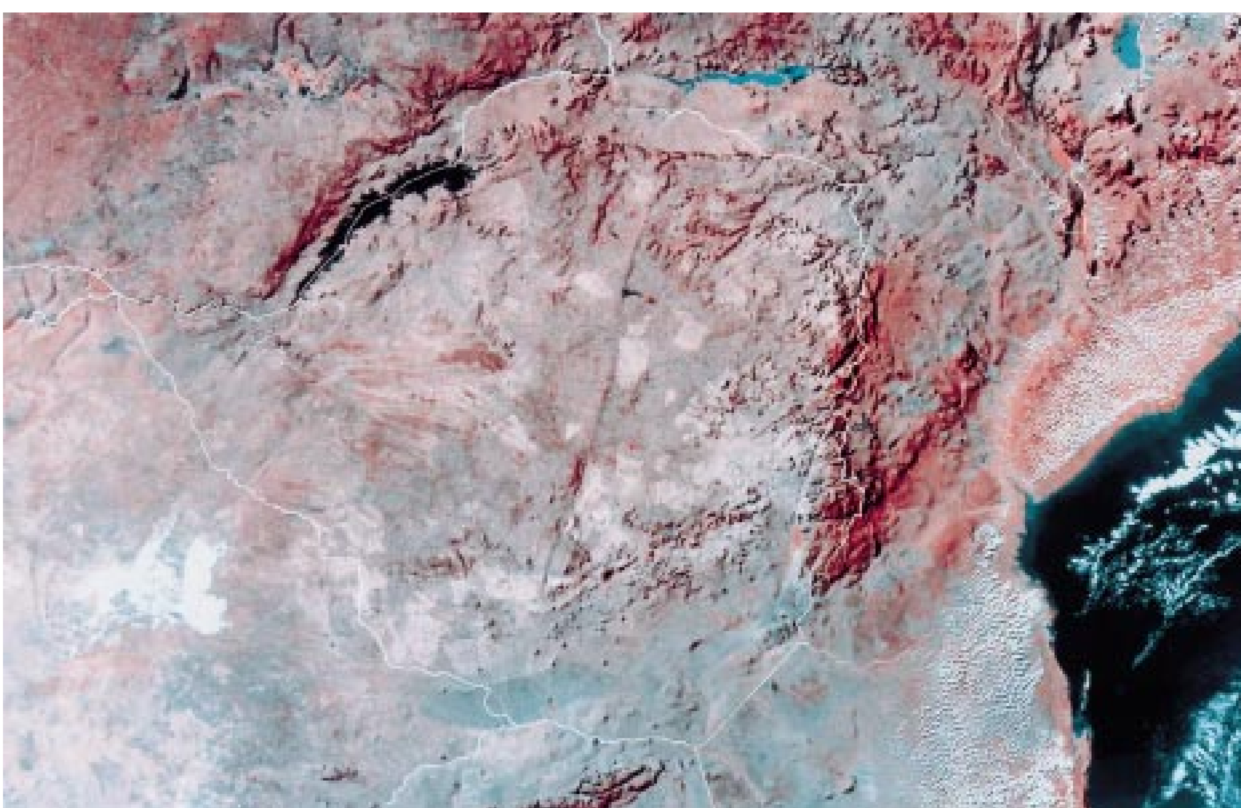

Figure 3b Zimbabwe July 6, 1990 satellite image map.

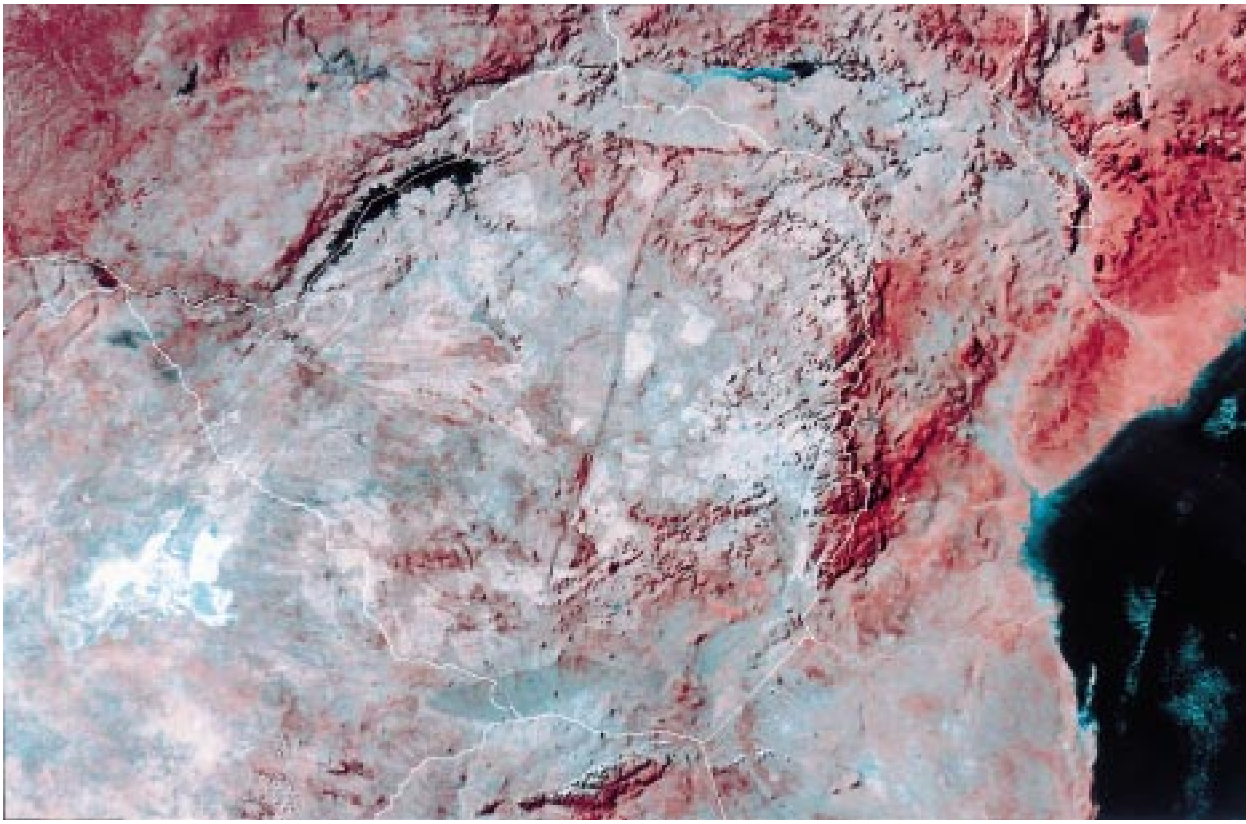

Figure 3c Zimbabwe April 16, 1995 satellite image map.

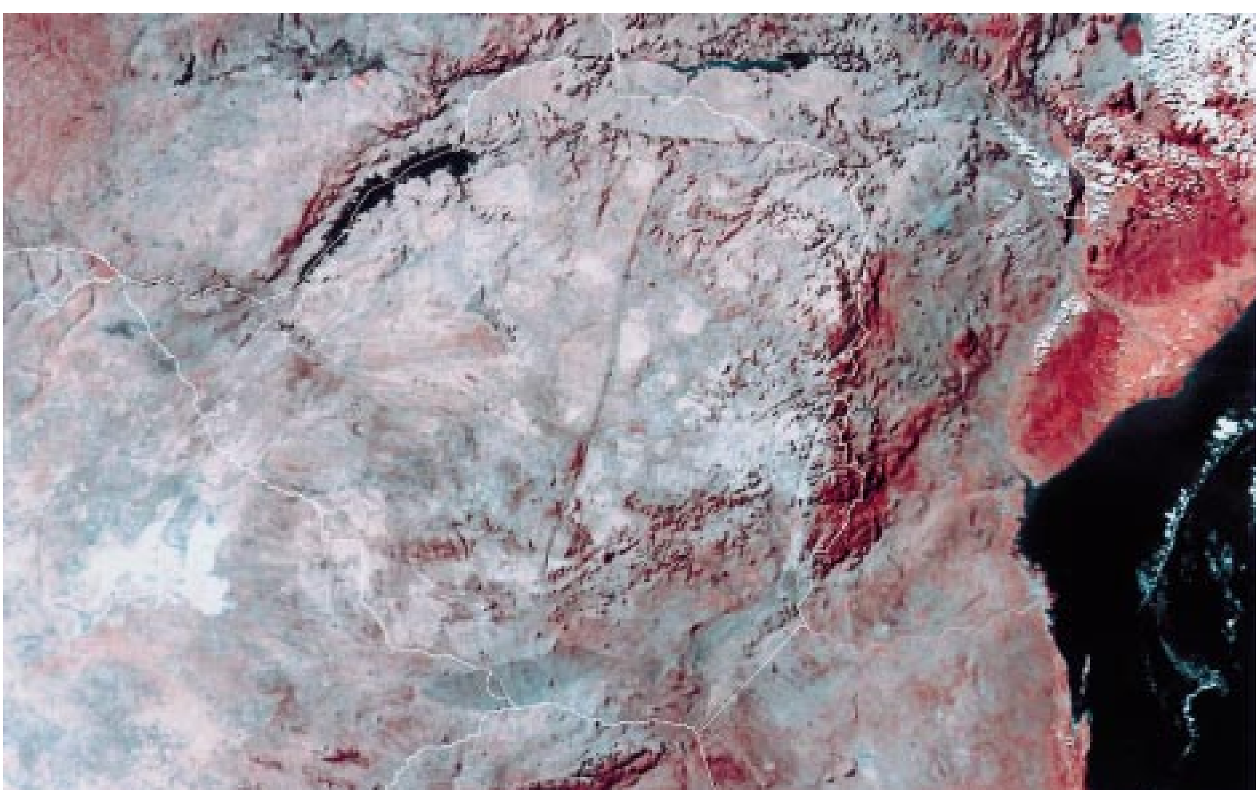

Figure 3d Zimbabwe July 9, 1995 satellite image map.

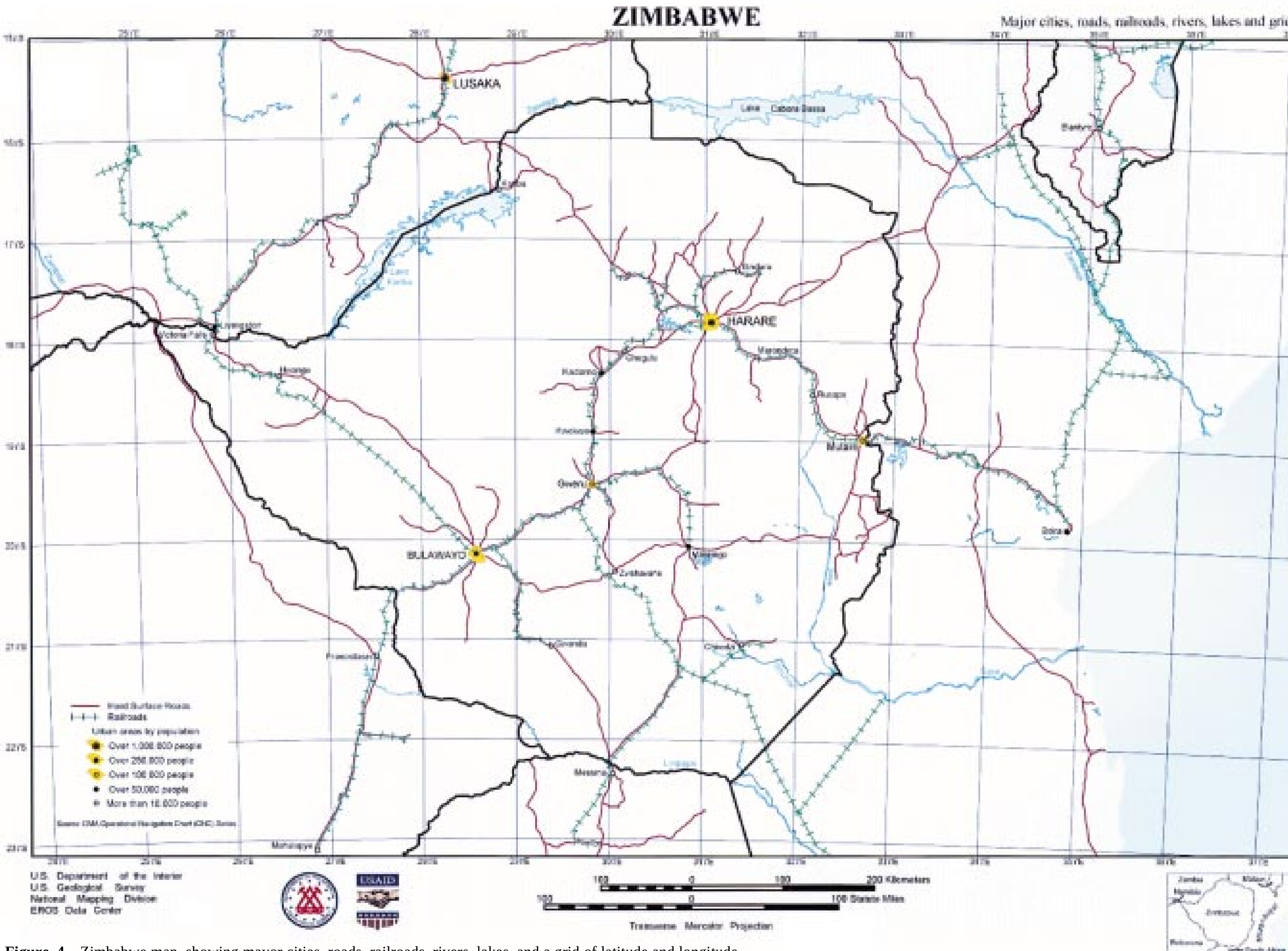

Figure 4 Zimbabwe map, showing mayor cities, roads, railroads, rivers, lakes, and a grid of latitude and longitude.

Zimbabwe's location in a rain shadow on a relatively arid plateau is indicated during a period of drought (Fig. 3c and 3d) by a general absence of vegetation and little vegetation along the country's eastern border, in contrast to the widespread vegetation, indicated by a dark red color, on the Mozambique side of the Zimbabwe/Mozambique border. The Zambezi River was dammed along the northwest border of Zimbabwe in 1959 to form Lake Kariba and in 1977 to form Lake Cabora Bassa (Figs. 3a, b, c, d and 4). For the Kariba Project, the installed hydroelectric capacity is rated at 1,500 MW, or 3 kW/hectare at the normal reservoir area of 510 000 ha, and for the Cabora Bassa Project, the installed capacity is rated at 4,000 MW, 14 kW/hectare at the normal reservoir area of 380 000 ha (Goodland, 1990). Although both reservoirs are impoundments of the Zambezi River, eutrophic (Gleick, 1991) Lake Kariba is divided by the international boundary of Zambia and Zimbabwe, and Lake Cabora Bassa lies within Mozambique (Fig. 4).

The three major cities in Zimbabwe are Harare, Bulawayo, and Mutare (Fig. 4). Both Harare and Mutare are along major rail and highway corridors to Beira, a Mozambican port on the Indian Ocean. Bulawayo, the second largest city in Zimbabwe is linked to Harare by rail and mayor road. Zimbabwe has rail links to contiguous neighbors Zambia, Botswana, South Africa, and Mozambique. Through Mozambique, Zimbabwe is linked by rail and road to Malawi. As a landlocked country, Zimbabwe is dependent upon Mozambique and South Africa for rail links to seaports for both importation and exportation.

The vegetative cover of Zimbabwe varies greatly in response to seasonal and longerterm climatic changes. November is usually the second month of the rainy season in Zimbabwe. The satellite image map of Zimbabwe on November 4, 1986, shows distribution of vegetation throughout most of the country. The absence of red in the white areas, throughout the country, and blue areas, predominately in the south, indicates little or no leafy vegetation. Such areas include rock, bare soil, woody vegetation with few leaves, or very sparse green vegetation.

July is in the middle of the dry season in Zimbabwe. On July 6, 1990, relatively little rainfed vegetation is detectable by satellite images (Fig. 3b). Irrigated areas are evident as small, red areas, particularly in the north and along the southeastern border with Mozambique. Northern Mozambique remains vegetated, although during the dry season there is little vegetation in southern Mozambique.

Rainfall was less than normal during the rainy season spanning 1994 and 1995 (USAID, 1995). Consequently, relatively little vegetation, other than irrigated cropland, was detectable on April 16, 1995 (Fig. 3c). Even though Zimbabwe suffered a severe drought, Mozambique, with access to humid air from the Indian Ocean, continued to have widespread vegetation, as indicated by vast expanses of red in the Mozambican areas of the April 16, 1995, satellite image map.

The severity of the 1994-95 drought is evident in the satellite image map of Zimbabwe for July 8, 1995 (Fig. 3d), when it is compared to the satellite image maps for July 6, 1990, and April 16, 1995. It is notable that the sea surface temperatures over the central Pacific Ocean were anomalously high in December 1994, a condition associated with the El Niño event that results in diminished rains in southern Africa (USAID, 1995). As early as October 1994, it was predicted, on the basis of changes in the El Niño/ Southern Oscillation conditions, that there was a strong possibility of a lower than average rainy season in Zimbabwe (USAID, 1995). The prediction is confirmed by the satellite image map derived from AVHRR data acquired on July 9, 1995 and by the final Zimbabwean government estimate of the production of the country's principal crop, maize, 839,600 metric tons (MT), which is 55 percent less than the 1.87 million MT ten-year average (USAID, 1995).

The final section of the atlas shows that the Republic of South Africa clearly has the most well developed rail and road infrastructure, followed by Zimbabwe (Fig. 2). The three largest natural lakes are significant aquatic ecosystems in the region defined by the SADC countries (UNEP, 1995):

Lake	Volume, km^3	Area, km^2	Maximum Depth, m
Victoria	2750	68 460	92
Tanganyika	18 900	32 900	1471
Nyasa	6141	22 490	706

These three lakes are rich with a wide range of fish species (Victoria > 240, Tanganyika > 250, and Nyasa > 260), and more than 80 percent of their fish species are endemic (UNEP, 1994). One of the great challenges in southern Africa is to mitigate the reduction of biodiversity and endemic species brought about by the activities of humans within the African Great Lakes. Cooperation among countries of the region will be necessary to protect such components of the environment that are held in common. Two artificial lakes in the region, Lake Kariba (160 km^3) and Lake Cabora Bassa (63 km^3) (Gleick, 1993) are, like the large natural lakes, significant aquatic ecosystems. In addition to the three large lakes and these two large reservoirs, there are smaller lakes, many of which are not detectable with AVHRR satellite images. The three major rivers of the region include the Orange (2100 km), which flows to the Atlantic Ocean, and the Zambezi (3500 km) and Limpopo (1800 km) (Milkman, 1983), which flow into the Indian Ocean. Annual sediment discharge (millions of tonnes per year) has been estimated to be 17 for the Orange, 20 for the Zambezi, and 33 for the Limpopo.

Conclusions

Production of the Atlas of Zimbabwe and the SADC brings together remotely sensed data and other data layers, in the form of image maps, to present a concise picture of the differences in the abundance and distribution of vegetation corresponding to seasonal and annual differences in rainfall. These maps show areas where drought can be expected to have its most profound impacts on the human environment, which is shared with other species of animals and plants. Aquatic ecosystems in the region are easy to locate on the overlays of hydrographic data and on the maps printed on white paper. Major roads and railroads, major populated places, and administrative boundaries clearly indicate imprints of humans on the physical environment. These atlases produced to meet the needs of diplomats are useful tools for decision makers to understand large areas of the environment that are affected by their decisions.

In the 32-page policy statement of the U.S. State Department entitled "Environmental Diplomacy," Vice President Albert Gore, Jr. wrote that the United States " ... foreign policy must now address a broad range of threats—including damage to the world's environment—that transcend countries and continents and require international cooperation to solve." As diplomats study environmental issues in the future, they will take advantage of tools such as this atlas, which is based on satellite image data and other digital data and composed using geographic information systems.

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