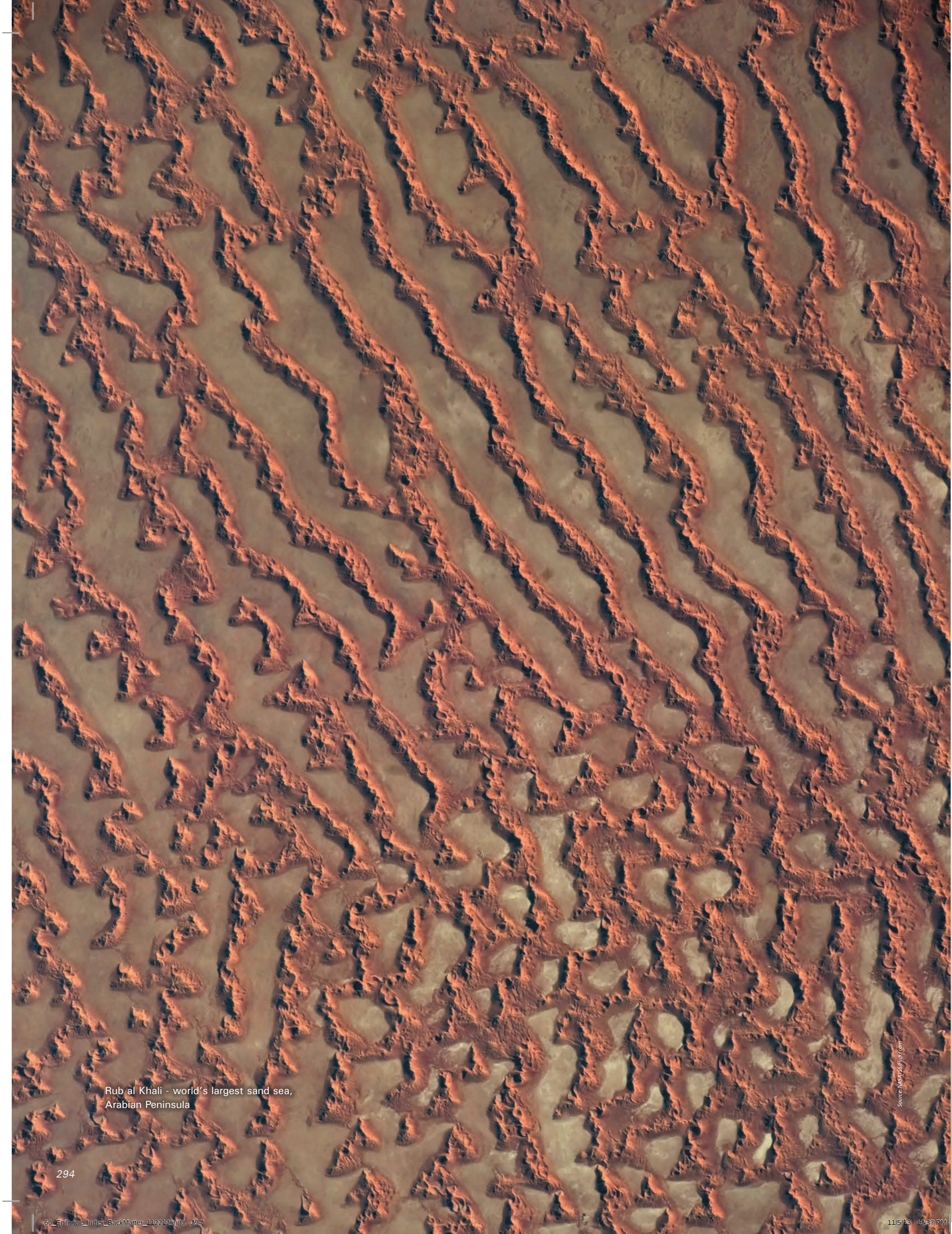

Rub al Khali - world's largest sand sea,
Arabian Peninsula

Source: NASA ISS/Flickr.com

Epilogue

"There was no water and too much sand…"

- Nofa Hamid, sheep herder from Addami village in Syria (NPR 2010)

In the drought-stricken village of Addami in northern Syria, villagers such as Nofa Hamid have abandoned their once-fertile lands that have turned to dust in search of work in cities. The massive displacement of 'water refugees' is happening region-wide in response to increasing water scarcity and climate change. Nofa Hamid, who has been tending sheep for almost 50 years said the summer had been 'crazy' and that the sand was 'everywhere'. Sheep herders and farmers who depend on their livestock and farmlands are being forced to seek other livelihoods - many find temporary jobs in urban areas; however, the future for many sheep herders like Nofa Hamid is uncertain given the increased temperatures and significant reductions in annual average rainfall expected in the Arab region as a result of climate change. The effects of water scarcity and displacement of peoples to cities ranges greatly from unchecked sprawl, lack of basic services, increasing food insecurity, and pollution. The environment is also affected by reduced biodiversity and exacerbated soil erosion, which increases desertification. The degradation of the landscape has far reaching consequences, both social and environmental.

Just as oil largely defined the past century for the Arab region, water scarcity and desertification will likely define this century. The drought conditions in the village of Addami and the migrations of people forced to seek other livelihoods, have become commonplace in the Arab region; these conditions will worsen with increases in population, and in some cases, by conflict. Chapter 2 of this atlas describes water availability and supply as a transboundary issue, which highlights the potential for coordination and collaboration among water-sharing countries, but also emphasizes the potential for conflict over an increasingly scarce natural resource. In response, the Arab League nations are investing substantial effort and funds into developing alternative water supplies, adopting water conservation measures, and planting more water efficient crops to mitigate growing water scarcity problems. Some countries are going to extraordinary lengths to increase water supplies, such as the case with Morocco's cloud seeding program in the Central High Atlas Mountains, where silver iodide is used as a seeding agent to increase the precipitation efficiency of cold clouds to produce snowfall and augment the snowmelt runoff in the summer, when the water is needed most. Other Arab countries are implementing extensive wastewater recycling programs and the Arab region boasts some of the largest desalination plants in the world.

With almost 40 per cent of the global population projected by 2015 to be living in countries where it is difficult or impossible to meet basic water needs, and over half of the Arab countries expected to experience severe water scarcity by 2050, these innovative methods are key to ensuring future water supplies. As the UN Committee on Economic, Social and Cultural Rights commented: 'Water is fundamental for life and health. The human right to water is indispensable for leading a healthy life in human dignity. It is a pre-requisite to the realization of all other human rights'. Efficient water management and coordinated approaches to managing increasingly scarce natural resources in the Arab region are fundamental to ensuring a secure future for the people of this region.

Acronyms and Abbreviations

ACSAD	Arab Center for Studies of Arid Zones and Drylands
AFED	Arab Forum for Environment and Development
ATDP	Arab Trade and Development Program
BCE	Before the Common Era
BCM	billion (thousand million) cubic metres
bpd	barrels per day
boe	barrels of oil equivalent
°C	Celsius
CAEU	Council of the Arab Economic Unity
CBD	Convention on Biological Diversity
CEDARE	Center for Environment and Development for the Arab Region and Europe
cm	centimeters
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DAC	Development Assistance Committee
EPA	Environmental Protection Agency
ESCWA	Economic and Social Commission for Western Asia
FAO	Food and Agriculture Organization of the United Nations
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GEF	Global Environment Fund
GEO	Group on Earth Observations
GHG	Greenhouse Gases
GIS	Geographic Information System
GNP	Gross National Product
GWh	Gigawatt Hour
ha	hectares
HDI	Human Development Indicator
HIPC	Heavily Indebted Poor Countries
IBAs	Important Bird Areas
IDPs	Internally displaced persons
IGBP	International Geosphere-Biosphere Programme
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature and Natural Resources
kg	kilograms
km	kilometres
km^2	square kilometres
km^3	cubic kilometres
LDCs	Least Developed Countries
m	metres
m^2	square metres
m^3	cubic metres
m^3/sec	cubic metres per second
Mashreq region	Egypt, Iraq, Jordan, Lebanon, Palestinian and Syria
Maghreb region	African nations of Algeria, Libya, Morocco, Tunisia and Mauritania
MCM	million cubic metres
MDRI	Multilateral Debt Relief Initiative
MDGs	Millennium Development Goals
mm	millimetres
MODIS	Moderate Resolution Imaging Spectoradiometer
MW	Megawatt
n.d.	no date
NO_2	Nitrogen Dioxide
NO_x	nitrogen oxides
N_2O	Nitrous Oxide
NASA	National Aeronautics and Space Administration, United States of America
NCSA	National Capacity Self Assessments
NOAA	National Oceanic and Atmospheric Administration, United States of America
O_3	ozone
OPEC	Organization of the Petroleum Exporting Countries
PCB	Polychlorinated biphenyl
PERSGA	Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden
ppm	parts per million
PM	particulate matter
ROPME	Regional Organisation for the Protection of the Marine Environment
RSA	ROPME Sea Area
RSGA	Red Sea and Gulf of Aden
SIDS	Small Island Developing States
SO_x	sulphur oxides
UAE	United Arab Emirates
µg	microgram
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
UNSD	United Nations Statistics Division
USAID	United States Agency for International Development
USGS	United States Geological Survey
WFP	World Food Programme
WHO	World Health Organization
WRI	World Resources Institute
WTO	World Trade Organization
WWF	World Wildlife Fund
yr	year

Changes in MDG Goal 7: Environmental Sustainability Indicators	Forested Land as % of Land Area		Protected area to total surface area, percentage		Access to Improved Water source (% of total population)		Access to Improved Sanitation (% of total population)		Slum Population as percentage of urban population	
Country Names	1990	2010	1990	2010	1990	2008	1990	2008	1990	2005
Algeria, People's Democratic Republic of	0.7	0.6	**6.23**	**6.24**	94	83	**88**	**95**	11.8	N/A
Bahrain, Kingdom of	**0**	**1.4**	**0.16**	**0.74**	100	100	97	97	0	0
Comoros, Union of the	6.5	1.6	0	0	**87**	**95**	**17**	**36**	65.4	68.9
Djibouti, Republic of	0.3	0.3	0.05	0.05	**77**	**92**	66	56	N/A	N/A
Egypt, Arab Republic of	**0**	**0.1**	**2.08**	**6.08**	**90**	**99**	**72**	**94**	**50.2**	**17.1**
Iraq	**1.8**	**1.9**	0.05	0.05	81	79	N/A	73	16.9	52.8
Jordan, Hashemite Kingdom of	1.1	1.1	**0.73**	**1.94**	97	96	N/A	98	**16.5**	**15.8**
Kuwait, State of	**0.2**	**0.3**	1.11	1.11	99	99	100	100	N/A	N/A
Lebanon	**12.8**	**13.4**	**0.33**	**0.36**	100	100	N/A	89	50	53.1
Libyan Arab Jamahiriya, Socialist People's	0.1	0.	0.11	0.11	54	54	97	97	35.2	N/A
Mauritania, Islamic Republic of	0.4	0.2	1.13	1.13	**30**	**49**	**16**	**26**	94.3	N/A
Morocco, Kingdom of	**11.3**	**11.5**	**1.13**	**1.53**	**74**	**81**	**53**	**69**	**37.4**	**13.1**
Oman, Sultanate of	0	0	**0**	**9.31**	**80**	**88**	85	N/A	60.5	N/A
Occupied Palestinian Territories	1.5	1.5	**0.63**	**0.64**	95	91	N/A	89	N/A	N/A
Qatar, State of	0	0	**0.89**	**1.39**	100	100	100	100	N/A	N/A
Saudi Arabia, Kingdom of	0.5	0.5	**7.25**	**29.95**	89	89	N/A	N/A	**19.8**	**18**
Somali Republic	13.2	10.8	0.53	0.53	**21**	**30**	N/A	23	**96.3**	**73.5**
Sudan, Republic of the	32.1	29.4	4.18	4.18	65	57	34	34	86.4	94.2
Syrian Arab Republic	**2**	**2.7**	**0.25**	**0.64**	**85**	**89**	**83**	**96**	10.4	10.5
Tunisia	**4.1**	**6.5**	**1.22**	**1.27**	**81**	**94**	**74**	**85**	**9**	**3.7**
United Arab Emirates	**2.9**	**3.8**	**0.27**	**4.71**	100	100	97	97	N/A	N/A
Yemen, Republic of	1	1	**0**	**0.69**	72	62	**18**	**52**	**67.5**	**67.2**

* Improvements are marked in **bold green**

Source used for country names: Permanent Mission to the United Nations, 2008.

Note: Some of the dates may vary along with the data sources- see the country profiles in Chapter 3 for further information

About Remote Sensing Images

The field of Remote Sensing has grown considerably since its infancy in the early 1970s when the initial earth-observing satellite of the Landsat program was launched. The Landsat program, jointly managed by NASA and the U.S. Geological Survey, has collected and archived images of the Earth's surface for nearly 40 years. This valuable historical record provides a unique opportunity for identifying and documenting environmental change anywhere on the planet. This atlas relies heavily, although not completely, on the images provided by the Landsat Program to depict environmental change in the Arab region. Since the initial earth-observing satellite of the Landsat Program was launched in the 1970s several new satellites with improved sensors (EO-1, OrbView, IKONOS etc.) collected data at higher resolutions and with an ability to capture different portions of electromagnetic radiation (e.g. radio waves, microwaves, visible light, infrared). The improved imagery from non-Landsat satellites proved invaluable in documenting change in the Arab region. Additionally, this atlas benefited from declassified satellite data, such as the images from the CORONA program, which allowed for documenting change in the Arab region from as early as the 1960s.

Satellites, like Landsat, use "multispectral" sensors to collect reflected electromagnetic energy from the visible range (400 to 700 nanometers), as well as wavelengths that the human eye cannot see (700 to 2 350 nanometers), and thermal energy to create images of the Earth. Multi-spectral sensors divide electromagnetic radiation into a small number of "bands" or ranges of wavelength. For example Landsat-7 collects electromagnetic radiation in eight different bands or ranges of wavelength (see table). Each of these ranges of "light" can tell us something different about the Earth's surface.

Creating usable and understandable images from multi-spectral sensors entails combining three or more of the available bands and displaying them as one of the three colours of standard monitor displays: red, green and blue. Often this yields an image that is not intuitive for the non-specialist to interpret (see the image at left, below). By selecting certain bands and adjusting the distribution of brightness - the overall brightness and the contrast - a more intuitive looking image can be achieved (see the image at right, below). The images in this atlas have been adjusted so that non-expert readers can interpret these images easily.

The specific sensors and the band combinations used in Chapter Three can be found in the references at the end of the chapter.

In general, images are displayed so that live vegetation shows as various shades of green. Coniferous forests are generally darker shades of green, as are mangroves. Broadleaf forests are typically depicted as a slightly brighter shade of green. Agricultural fields with actively growing crops are shown as an even brighter shade of green; however this is dependent on the crop and its state of growth. The patterns of brightness are often important clues as to the nature of the vegetation. Senescent or inactive vegetation generally appears as shades of grey and brown.

Water bodies are often blue to black in appearance; however when sediment is present or the water is shallow it will appear lighter, even taking on a pink caste. Areas of bare ground will show as bright, usually almost white, while urban areas and roads generally appear as a shade of pale purple. Clouds, when they cannot be avoided, will appear as bright white.

As mentioned above, data from other sensors, such as ASTER[1] and MODIS[2], as well as the high resolution commercial sensors QuickBird[3] and IKONOS[4], were used in the production of this atlas. Readers will note the number of black and white images in the atlas, which were collected by the declassified satellite CORONA[5]. Corona was the United States first photo reconnaissance satellite system, operating from August 1960 until May 1972. The program was declassified in February 1995.

Landsat-7 ETM+Bands		
Band	**Spectral Range (nm)**	**Description**
1	450 to 515 nm	blue-green light
2	525 to 605 nm	green light
3	630 to 690 nm	red light
4	775 to 900 nm	near-infrared radiation
5	1 550 to 1 750 nm	mid-infrared radiation
6	10 400 to 12 500 nm	thermal-infrared radiation
7	2 090 to 2 350 nm	mid-infrared radiation
8	520 to 900 nm	pan-chromatic

Both of these images are from the same ASTER remote sensing image taken over Baghdad, Iraq in August of 2009. On the left, image bands are shown as red, green and blue, with the contrast and brightness determined by the default settings of a standard Geographic Information System software program. On the right, bands are displayed as red, green and blue and the colour balance, contrast and brightness have been adjusted.

1 ASTER (The Advanced Spaceborne Thermal Emission and Reflection Radiometer) is a sensor aboard the TERRA satellite is a joint effort between National Aeronautics and Space Administration (NASA) and Japan's Earth Remote Sensing Data Analysis Center (ERSDAC).
2 MODIS (Moderate Resolution Imaging Spectroradiometer) is a sensor carried on NASA's TERRA and AQUA satellites.
3 QuickBird is a high resolution commercial multispectral sensor aboard the QuickBird satellite, operated by DigitalGlobe.
4 IKONOS is a high resolution commercial multispectral sensor aboard GeoEye's IKONOS satellite.
5 Corona is a U.S. photographic surveillance satellite flown from the 1960s through the 1970s.

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Collaborating Partners

eMISK
Environment Public Authority, Kuwait
Regional Organization for the Protection of the Marine Environment

Atlas Production Team

Core Team

Adel Abdel-Kader, UNEP
Ashbindu Singh, UNEP
Matthew Broughton, UNEP
Yasmina Adra, UNEP (formerly)
Cathrine Armour, AGEDI (formerly)
Faris Sayegh, Geographic Planning Collaborative, Inc (formerly)
Jane Glavan, AGEDI
Zach Hill, Ecosystem Sciences

Coordinating Lead Authors

Shannon Campbell, Ecosystem Sciences
Zach Hill, Ecosystem Sciences

Scientific and Technical Editor

Shannon Campbell, Ecosystem Sciences

Mapping and Cartography

Tim Maguire, Ecosystem Sciences
Zach Hill, Ecosystem Sciences

Reviewing Editor

Yasmin Aziz, UNEP Consultant

Design, Layout and Graphics

Zach Hill, Ecosystem Sciences

Satellite Image Processing and Scientific Research

Aditya Agrawal, Geographic Planning Collaborative, Inc
Bruce Pengra, UNEP
Derek Risso, Ecosystem Sciences
Tim Maguire, Ecosystem Sciences
Zach Hill, Ecosystem Sciences

Scientific Data and Research Support Team

Rania Bou Kheir, Lebanese University
Tamsen Binggeli, Ecosystem Sciences
Zach Herzfeld, Ecosystem Sciences

Web Development

Michelle Anthony, UNEP

Lead Authors

Abdullah Droubi, ACSAD (formerly)
Ahmed El-Kholei, Menofia University
Farid Chaaban, American University of Beirut
Karim Jisr, Ecodit
Mahmoud Khamis El-Sayed, Alexandria University
Mohammad S. Abido, Damascus University/Arabian Gulf University
Mohammad Khawlie, National Centre for Remote Sensing
Rami Zurayk, American University of Beirut
Shannon Campbell, Ecosystem Sciences (formerly)
Tim Maguire, Ecosystem Sciences
Zach Hill, Ecosystem Sciences

Other Contributors

Abdellatif Elmahrari, Morocco
Abdu Solh, Yemen
Ahmad Hussein Abdul Rahman, Qatar
Al Mahdi Rahmani, Qatar
Andrew Bauman, Canada
Balgis Elasha, Sudan
Chadi Badra, Syria
David Feary, Canada
Edwin Grandcourt, UAE
Enas Obeidat, Jordan
Fahad Alarifi, Saudi Arabia
Ghada Mahmoud, Egypt
Hassan Mohammadi, ROPME, Kuwait
Huda Al-Munayes, Kuwait
Huda Al Houqani, UAE
Hussein Shahin, Jordan
John Burt, UAE
Joy Jadam, Lebanon
Kamel Sheikho, Saudi Arabia
Khaled Salem, Occupied Palestinian Territories
Marwan Dimashki, eMISK, Kuwait
Mohamed Dawoud, UAE
Mohammad Dawod Al-Ahmad, eMISK, Kuwait
Mohammed Bukhari, Saudi Arabia
Mohammed Al-Ghamdi, Saudi Arabia
Mona Kamal, Egypt
Morad Sola, Libya
Mouza Al Mansouri, UAE
Mubarak Khalifa Al-Dosari, Qatar
Myyas Al Quarqaz, UAE
Nasra Al-Harthy, Oman
Nouri Soussi, Tunisia
Patty Farah, Lebanon
Rashid Al Kuwari, Qatar
Saadeldin Mohamed, Sudan
Saif Al-Bahry, Oman
Sanaa Sairawan, Lebanon
Suhad Al Shehabi, Bahrain
Wisam Mohammed, Bahrain
Yasser Othman, UAE
Zainab AlHerz, Bahrain

Reviewers

Adel Yehia, EIN Shams University
Ali Amasha, Regional Center for Disaster Risk Reduction
Anil Kumar, Environment Agency Abu Dhabi
Asma Abahussain, Arabian Gulf University
Derek Risso, Ecosystem Sciences
Edwin Grandcourt, Environment Agency Abu Dhabi
Essam Ahmed, Egyptian Environmental Affairs Agency
Faris Sayegh, Geographic Planning Collaborative, Inc
Hesham Mohamed, Arabian Gulf University
Islam Abou El-Magd, CSci, National Authority for Remote Sensing and Space Sciences - Egypt
Jane Glavan, Environment Agency Abu Dhabi
Khaled Salem, Environment Quality Authority - Palestine
Laila Al Hassan, Environment Agency Abu Dhabi
Mahmoud Ali Abdelfattah, Environment Agency Abu Dhabi
Mark Hill, Ecosystem Sciences
Mohamed Dawoud, Environment Agency Abu Dhabi
Mohammad Abido, Arabian Gulf University
Mostafa Foda, Egyptian Environmental Affairs Agency
Peter Petrov, Regional Organization for the Protection of the Marine Environment
Rabah Lahmar, UR Systemes de Culture Annuels
Richard Perry, Environment Agency Abu Dhabi
Scot Smith, University of Florida
Wadid Erian, Arab Center for the Study of Arid Zones and Dry Lands

UNEP Extended Team

Charles Davies
Charles Sebukeera
Frank Turyatunga
Habib El-Habr
Iyad Abumoghli
Melanie Hutchinson
Mona Radwan
Monika MacDevette
Peter Gilruth

EAD Extended Team

Anil Kumar
Edwin Grandcourt
Entesar Al Hosani
Huda Al Houqani
Mohamed Dawoud
Mouza Al Mansouri
Yasser Othman

Outreach and Communications

Larissa Owen, AGEDI
Marie Daher Corthay, UNEP
Neeyati Patel, UNEP
Nick Nuttall, UNEP

Source: NASA ISS/Flickr.com