Geoinformatics: definition, concepts, tools and techniques and issues in Nepalease agriculture

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Outline

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Meaning and definition

- Science and technology dealing with the structure and character of spatial information, its capture, its classification and quantification, its storage, processing, portrayal and dissemination, including the infrastructure necessary to secure optimal use of this information.
- Categorized under technical geography
- Relies upon the theory and practical implications of geodesy.
- Geography and earth science increasingly rely on digital spatial data acquired from remotely sensed images analyzed by geographical information systems (GIS), photo interpretation of aerial photographs

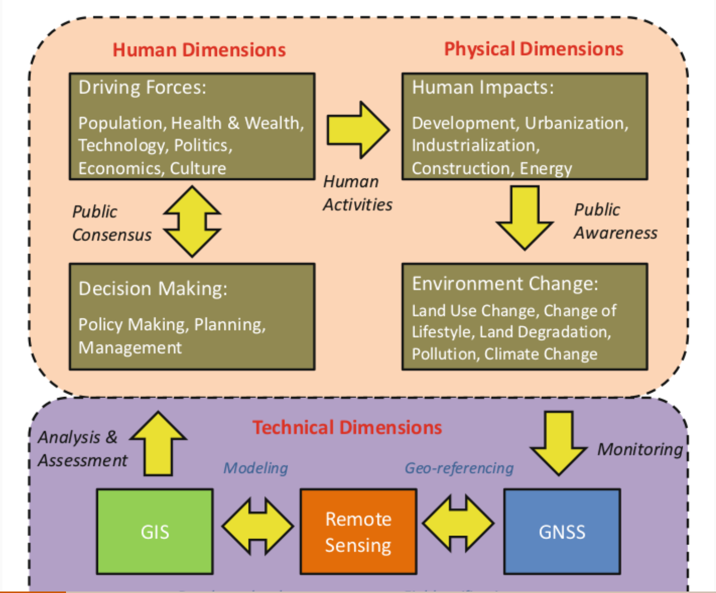
- For analysis of geographic information:
  - geospatial analysis and modeling (geocomputation),
  - geovisualization
- Also deals with:
  - development of geospatial databases,
  - information systems design,
  - human-computer interaction and
  - wired and wireless networking technologies

Areas of geoinformatics

- Cartography
- Geodesy
- Satellite navigation
- Photogrammetry
- Remote sensing
- Spatial analysis
- Web mapping
- Navigation

Digital earth

- Digital Earth is the name given to a concept coined by former US vice president Al Gore in 1998, that describes a virtual representation of the Earth that is spatially referenced and interconnected with the world's digital knowledge archives. Furthermore, the greater part of this knowledge store would be free to all via internet.
- The global dimension of the digital earth concept is perhaps best captured by two excerpts from Beijing declaration on digital Earth:
    - Digital earth is an integral part of other advanced technologies including: Earth observation, geo-information system, global positioning systems, communication networks, sensor webs, electromagnetic identifiers, virtual reality, grid computation, etc. It is seen as a global strategic contributer to scientific and technological developments, and will be a catalyst in finding solutions to international scientific and societal issues;
    - Digital earth should play a strategic and sustainable role in addressing such challenges to human society as natural resource depletion, food and water insecurity, energy shortages, environmental degradation, natural disaster response, population explosion, and, in particular, global climate change.


Human Dimensions
Physical Dimensions
Driving Forces:
Population, Health & Wealth, Technology, Politics, Economics, Culture
Human Activities
Human Impacts:
Development, Urbanization, Industrialization, Construction, Energy
Public Consensus
Public Awareness
Decision Making:
Policy Making, Planning, Management
Environment Change:
Land Use Change, Change of Lifestyle, Land Degradation, Pollution, Climate Change
Technical Dimensions
Analysis & Assessment
Monitoring
Modeling
Geo-referencing
GIS
Remote Sensing
GNSS

Applications

- Urban planning and land use management,
- in-car navigation systems,
- virtual globes,
- public health,
- local and national territory management,
- environmental modeling and analysis,
- military,
- transport network planning and management,
- agriculture,
- meteorology and climate change,
- oceanography and atmosphere modeling,
- business location planning,
- architecture and archaeological reconstruction,
- telecommunications,
- criminology and crime simulation,
- aviation and maritime transport
- biodiversity conservation

Outline

Cartography

- Study and practice of making and using maps. Combining science and aesthetics and technique, cartography builds on the premise that reality can be modeled in ways that communicate spatial information effectively.
- Coordinate reference system defines how the visual mapping of spatial data should be done
  - CRS has projection parameters, which is configurable giving a variation in mapping [1].
- Objectives of traditional cartography:
  - Set the map agenda and select traits (roads, land masses, political boundaries) of the object to be mapped.
  - Represent the terrain of the mapped object on flat media (projection)
  - Reduce the complexity (generalization).
  - Organize the elements of the map to best convey its message (map design)
- Modern cartography constitutes theoretical and practical foundations of GIS and Geographic information science[2].

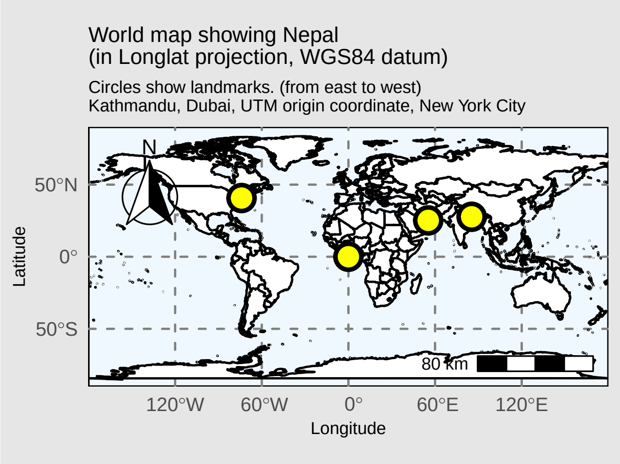
[1] https://proj.org/usage/projections.html

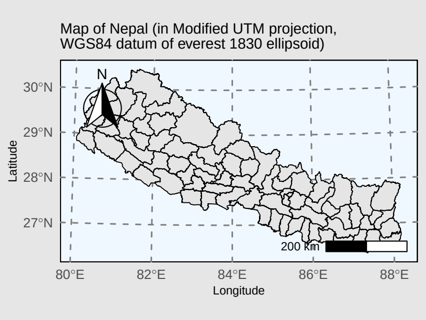
[2] Overview of CRS (in R) is available at: https://www.nceas.ucsb.edu/sites/default/files/2020-

Map types

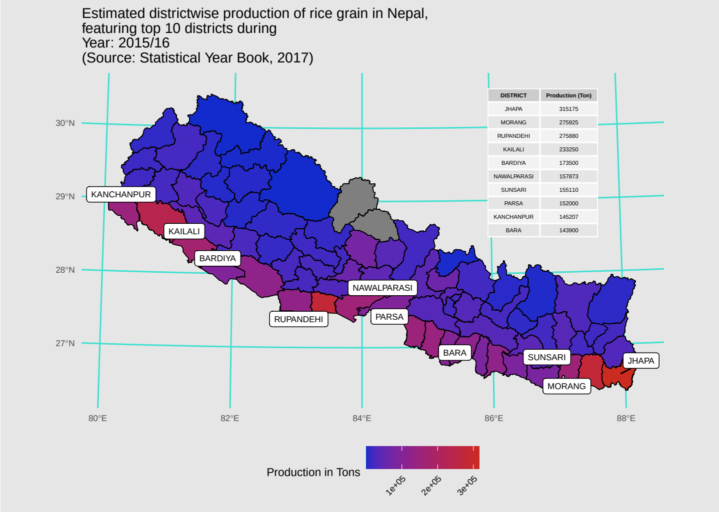
- General vs. thematic cartography
  - General:
    - Intended for general audience and containing a variety of features. Bear many reference and location systems.
  - Thematic:
    - Specific geographic themes
    - Oriented toward specific audiences
    - Dot map showing corn production in different districts of Nepal divided into numerical choropleth classes.
    - With the increasing volume of geographic data, thematic cartography has become increasingly useful and necessary to interpret spatial, cultural and social data

General cartography





Thematic cartography



DISTRICT	Production (Ton)
JHAPA	315175
MORANG	275925
RUPANDEHI	275880
KAILALI	233250
BARDIYA	173500
NAWALPARASI	157873
SUNSARI	155110
PARSA	152000
KANCHANPUR	145207
BARA	143900

Projections

- Projections map the spherical 3D space to a flat 2D space [3].
- Projections are coordinate operations that are technically conversions but since projections are so fundamental to PROJ we differentiate them from conversions.

Projection	Projection	Projection	Projection	Projection	Projection	Projection	Projection	Projection	Projection
Adams Hemisphere in a Square	Cassini (Cassini-Soldner)	Eckert VI	Modified Stereographic of 50 U	Laborde	McBryde-Thomas Flat-Polar Sinusoidal	New Zealand Map Grid	Putnins P4’	Oblique Stereographic Alternative	van der Grinten II
Adams World in a Square I	Central Cylindrical	Equidistant Cylindrical (Plate Carrée)	Guyou	Lambert Azimuthal Equal Area	Mercator	General Oblique Transformation	Putnins P5	Gauss-Schreiber Transverse Mercator (aka Gauss-Laborde Reunion)	van der Grinten III
Adams World in a Square II	Central Conic	Equidistant Conic	Hammer & Eckert-Greifendorff	Lagrange	Miller Oblated Stereographic	Oblique Cylindrical Equal Area	Putnins P5’	Transverse Central Cylindrical	van der Grinten IV
Albers Equal Area	Equal Area Cylindrical	Equal Earth	Hatano Asymmetrical Equal Area	Larrivee	Miller Cylindrical	Oblated Equal Area	Putnins P6	Transverse Cylindrical Equal Area	Vitkovsky I
Azimuthal Equidistant	Chamberlin Trimetric	Euler	HEALPix	Laskowski	Space oblique for MISR	Oblique Mercator	Putnins P6’	Times	Wagner I (Kavrayskiy VI)
Airy	Collignon	Fahey	rHEALPix	Lambert Conformal Conic	Mollweide	Ortelius Oval	Quartic Authalic	Tissot	Wagner II

[3] https://proj.org/usage/projections.html

Tools and techniques

Projection	Projection	Projection	Projection	Projection	Projection	Projection	Projection	Projection	Projection
Aitoff	Colombia Urban	Foucaut	Interrupted Goode Homolosine	Lambert Conformal Conic Alternative	Murdoch I	Orthographic	Quadrilateralized Spherical Cube	Transverse Mercator	Wagner III
Modified Stereographic of Alaska	Compact Miller	Foucaut Sinusoidal	Interrupted Goode Homolosine (Oceanic View)	Lambert Equal Area Conic	Murdoch II	Patterson	Robinson	Tobler-Mercator	Wagner IV
Apian Globular I	Craster Parabolic (Putnins P4)	Gall (Gall Stereographic)	Interrupted Mollweide	Lee Oblated Stereographic	Murdoch III	Perspective Conic	Roussilhe Stereographic	Two Point Equidistant	Wagner V
August Epicycloidal	Denoyer Semi-Elliptical	Geostationary Satellite View	Interrupted Mollweide (Oceanic View)	Loximuthal	Natural Earth	Peirce Quincuncial	Rectangular Polyconic	Tilted perspective	Wagner VI
Bacon Globular	Eckert I	Ginsburg VIII (TsNIIGAiK)	International Map of the World Polyconic	Space oblique for LANDSAT	Natural Earth II	Polyconic (American)	S2	Universal Polar Stereographic	Wagner VII
Bertin 1953	Eckert II	General Sinusoidal Series	Icosahedral Snyder Equal Area	McBryde-Thomas Flat-Polar Sine (No	Nell	Putnins P1	Spherical Cross-track Height	Urmaev V	Web Mercator / Pseudo Mercator
Bipolar conic of western hemisphere	Eckert III	Gnomonic	Kavrayskiy V	McBryde-Thomas Flat-Pole Sine (No	Nell-Hammer	Putnins P2	Sinusoidal (Sanson-Flamsteed)	Urmaev Flat-Polar Sinusoidal	Werenskiold I
Boggs Eumorphic	Eckert IV	Goode Homolosine	Kavrayskiy VII	McBride-Thomas Flat-Polar Parabolic	Nicolosi Globular	Putnins P3	Swiss Oblique Mercator	Universal Transverse Mercator (UTM)	Winkel I
Bonne (Werner lat_1=90)	Eckert V	Modified Stereographic of 48 U	Krovak	McBryde-Thomas Flat-Polar Quartic	Near-sided perspective	Putnins P3’	Stereographic	van der Grinten (I)	Winkel II
Cal Coop Ocean Fish Invest Lines/Stations									Winkel Tripel

EPSG codes for commonly used CRS (in the U.S.)

1. Latitude/Longitude
   - WGS84 (EPSG: 4326)
   - Commonly used by organizations that provide GIS data for the entire globe or many countries. CRS used by Google Earth
2. NAD83 (EPSG:4269)
   - Most commonly used by U.S. federal agencies.
3. NAD27 (EPSG: 4267)
   - Old version of NAD83
4. Projected (Easting/Northing)
   - UTM, Zone 10 (EPSG: 32610)
   - Zone 10 is used in the Pacific Northwest
5. Mercator (EPSG: 3857); Tiles from Google Maps, Open Street Maps, Stamen map

Universal Transverse Mercator

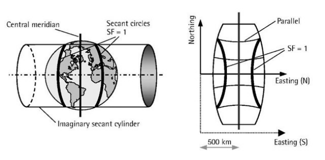
UTM coordinate comprises a zone number, a hemisphere (N/S), an easting and a northing. Eastings are referenced from the central meridian of each zone, & northings from the equator, both in metres. To avoid negative numbers, 'false eastings' and 'false northings' are used:

Eastings are measured from 500,000 metres west of the central meridian. Eastings (at the equator) range from 166,021m to 833,978m (the range decreases moving away from the equator); a point on the the central meridian has the value 500,000m.

In the northern hemisphere, northings are measured from the equator - ranging from 0 at the equator to 9,329,005m at 84 degree N). In the southern hemisphere they are measured from 10,000,000 metres south of the equator (close to the pole) - ranging from 1,116,915m at 80 degree S to 10,000,000m at the equator.

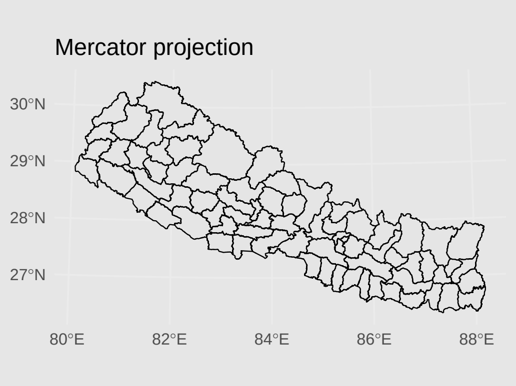
Nepal lies in the UTM zone of 440N and 450N. The scale factor is 0.9996 for the central meridian. 10 49' east or west of central meridian has the scale factor of 1.

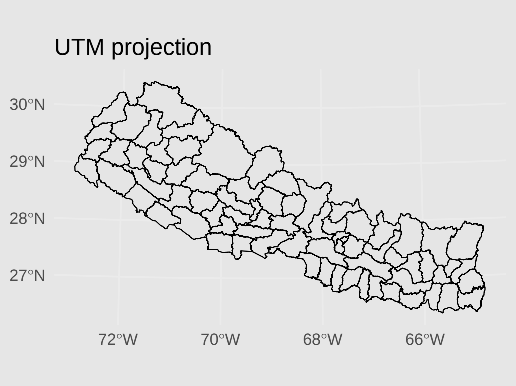
Norway/Svalbard: the designers of UTM made two exceptions to the rule. The part of zone 31 covering western Norway is transferred to zone 32, and the zones covering Svalbard are tweaked to keep Svalbard in two zones (it's easier to understand looking at a map). These widened zones are viable partly because zones are much narrower so far north, so little precision is lost in merging them.

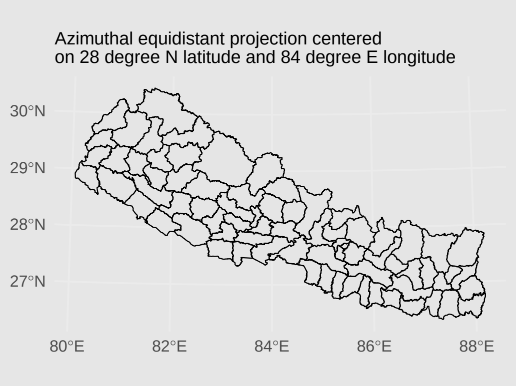


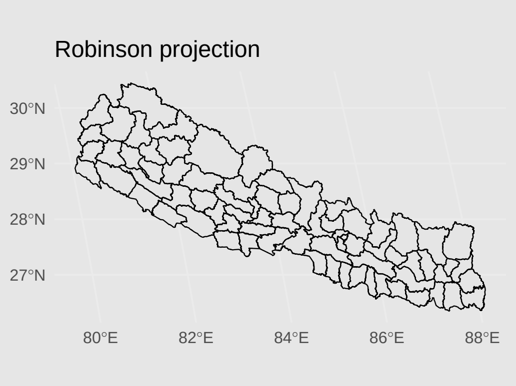
- Traditionally Universal Transverse Mercator (UTM) Projection system has been in use in Nepal; Mercator projection is Conformal Cylindrical Projection.
- In Transverse projection, Earth is wrapped around a cylinder in such a manner that point of tangency between Globe and Cylinder is a meridian, or line of longitude, called Central Meridian. In Conformal or Orthomorphic Projection, the shape/angle is preserved even though the length and breadth may distort.
- UTM consists total of 60 zones of longitude each of 60 extending from 180 W to 180 E. 180 W to 174 W is designated as zone 1 with the central meridian of 177 W and other zone goes as so on and so further manner. Further zone are divided in rows with a difference of 8. These zone extend from 80 S Latitude to 84 N latitude. The first Latitude zone is designated with letter C for 80 S to 72 S latitude.
- In recent years with cadastral survey and various accuracy techniques, Nepal has default projection set to MUTM (Modified UTM) – a Gauss-Krueger projection-based coordinate system. In this system, earth is divided in 120 zones each of 3 degree.
- Nepal has central meridian of 81 degree, 84 degree and 87 degree.
- Scale factor of 0.9999 is used for central meridian normally for 84 degree and 0 degree 55 minutes east or west of central meridian has the scale factor of 1 (meaning no distortion).
- False Easting at central meridian is 500,000 m in order to keep all the coordinates within the country positive, and False Northing at the Equator is 0 m.

```
## Coordinate Reference System:
##   User input: EPSG:26919
##   wkt:
## PROJCRS["NAD83 / UTM zone 19N",
##     BASEGEOGCRS["NAD83",
##         DATUM["North American Datum 1983",
##             ELLIPSOID["GRS 1980",6378137,298.257222101,
##                 LENGTHUNIT["metre",1]]],
##         PRIMEM["Greenwich",0,
##             ANGLEUNIT["degree",0.0174532925199433]],
##         ID["EPSG",4269]],
##     CONVERSION["UTM zone 19N",
##         METHOD["Transverse Mercator",
##             ID["EPSG",9807]],
##         PARAMETER["Latitude of natural origin",0,
##             ANGLEUNIT["degree",0.0174532925199433],
##             ID["EPSG",8801]],
##         PARAMETER["Longitude of natural origin",-69,
##             ANGLEUNIT["degree",0.0174532925199433],
##             ID["EPSG",8802]],
##         PARAMETER["Scale factor at natural origin",0.9996,
##             SCALEUNIT["unity",1],
##             ID["EPSG",8805]],
##         PARAMETER["False easting",500000,
##             LENGTHUNIT["metre",1],
##             ID["EPSG",8806]],
##         PARAMETER["False northing",0,
##             LENGTHUNIT["metre",1],
##             ID["EPSG",8807]]],
##     CS[Cartesian,2],
##         AXIS["(E)",east,
##             ORDER[1],
```


Mercator projection
30°N
29°N
28°N
27°N
80°E
82°E
84°E
86°E
88°E


UTM projection
30°N
29°N
28°N
27°N
72°W
70°W
68°W
66°W


Azimuthal equidistant projection centered
on 28 degree N latitude and 84 degree E longitude
30°N
29°N
28°N
27°N
80°E
82°E
84°E
86°E
88°E


Robinson projection
30°N
29°N
28°N
27°N
80°E
82°E
84°E
86°E
88°E

Use in precision agriculture

1. Agricultural mapping
   - Current and future variations in the rainfall
   - Crop output and temperature of the soil
   - Farm resource and structure mapping
2. Soil analysis
   - Mapping of soil type and crop suitability
   - Nutrient and fertilizer status mapping
3. Data combination
   - Realistic appraisal of farm production to assist insurance
   - Farmers could access data of their crops across the seasons to compare and contrast

4 Increased interaction

- Humans have better sense of space and time than any other variables
- Using machinery and GIS (including on-ground data), interventions could be more efficiently and effectively applied.

5 Assembly of information to develop systems based models

- Various layers of information such as soil moisture, nutrients, elevation, topography, irradiance, cloud cover, etc. could aid in feeding into growth models
- These could be translated into recommendation systems for precise implementation.

6 Real-time mapping
7 Raising alert and disaster mapping
8 Historical data comparison
9 Boosting production

Outline

Current state

- GIS based technology has already permeated through engineering discipline and seen its applications.
- Recently, natural resource management (forest, watershed) operations also have begun making use of geo-spatial data.
  - tracking of forest and shrubland coverage using geo-spatial data
  - monitoring of wildlife species using GPS tracker
- Agriculture have a long experience of poor information management system, which is in-part responsible for its dwindling state

Issues and concerns

- Although input availability and use are major factors affecting production, decision making on farmer level regarding these issues are still not informed by data
- Most farmers are resource poor and non-commercial cultivators
    - only heavily mechanized farmholds can exploit technology at fullest.
    - geoinformatic technologies only provides benefit at scales
- Data management and computational environments are not tailored for use among farmers in Nepal
- Only limited open database provide contextual data relevant for Nepal
- Data publications by government institution are very unorganized and contingent.
- Data privacy issues

- Most farmers are reluctant to trust computer or digital systems for decision making, due to
  - farmers do not have knowledge of how information systems work
  - systems being still immature have sometimes produced unreliable outcomes
- Government is still ignorant of the possibilities geo-informatics has for agriculture system

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References