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Feeding over 500 million livestock units in India

A tentative retro-prospective model (1966-2050)

Provisional results

Bruno DORIN (CIRAD-Montpellier, CIRED-Paris, CSH-Delhi)
Damien GAROYAN (CSH-Delhi, 2015-16)
Akshay MAHADEVAN (CSH-Delhi, 2019)
Sreenita MONDAL (CSH-Delhi, 2018)
Chloé MOREL (CSH-Delhi, 2019)
Anmol SEHGAL (CSH-Delhi, 2019)

International seminar "Milk and Dairy in India's Development Path"
New Delhi, 17-18 December 2019

Key messages

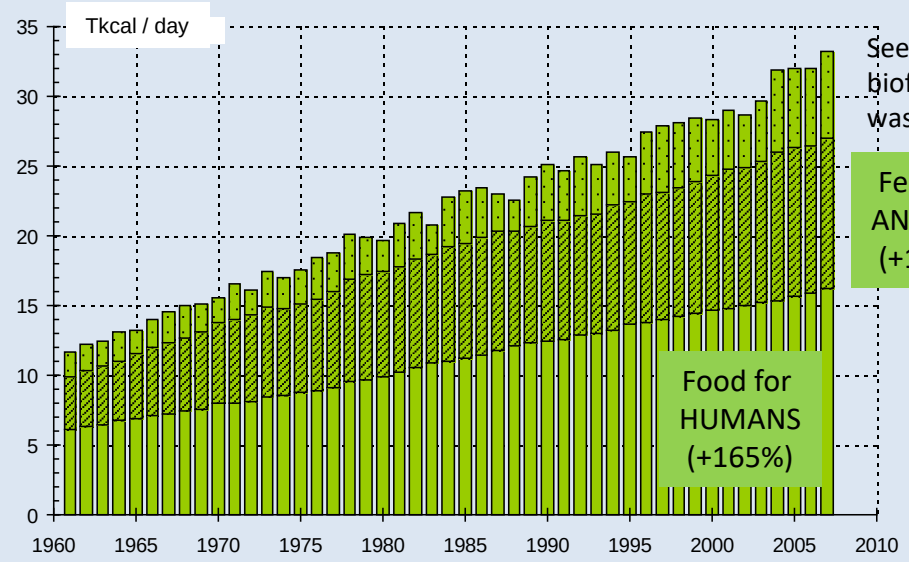
1. Globally, growing consumptions and productions
   of **animal products** (meat, milk…) and **animal feed** (cereals, oilcakes…)
   have **huge environmental impacts**
   (deforestation, CH_4 and N_20 emissions, energy and water consumptions…)
   and **challenge** both **food security** (food/feed competition for poor/rich consumer)
   and **food sovereignty** of land-squeezed countries (e.g. China, or even EU)
2. **India** is a confusing case in this storyline,
   but its **unique model** is **very poorly documented**,
   starting with national statistics on production and consumption of feeds,
   leading to diverging or inconsistent results from national/international models
3. Using the current state of the art (NIANP 2003, Gorti et al 2012…)
   we have extended and improved past assessments and bio-modelling
   to better project future scenarios and their impacts
   for an Indian population
   that is expected to peak at 1.723 billion people in 2071 (IIASA 2018)

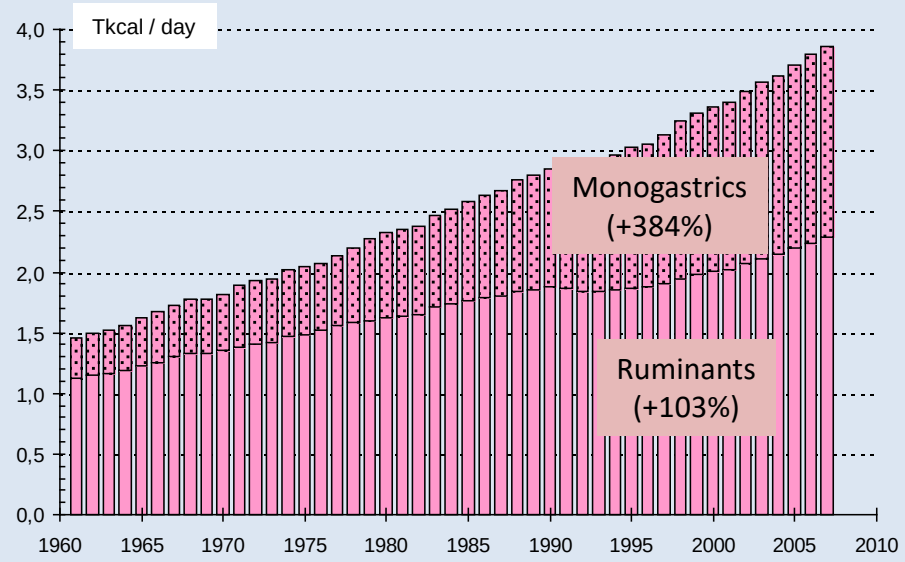
All in all: Livestock feed and human consummation of animal products
have been largely overlooked by most Indian stakeholders focused on foodgrains
(statisticians, economists, agricultural scientists, nutritionists, environmentalists, policy makers…)
and this must change urgently and drastically: we tried to work in this direction…

1 The global challenge

Global past picture: growing food crops for feeding livestock (1961-2007)

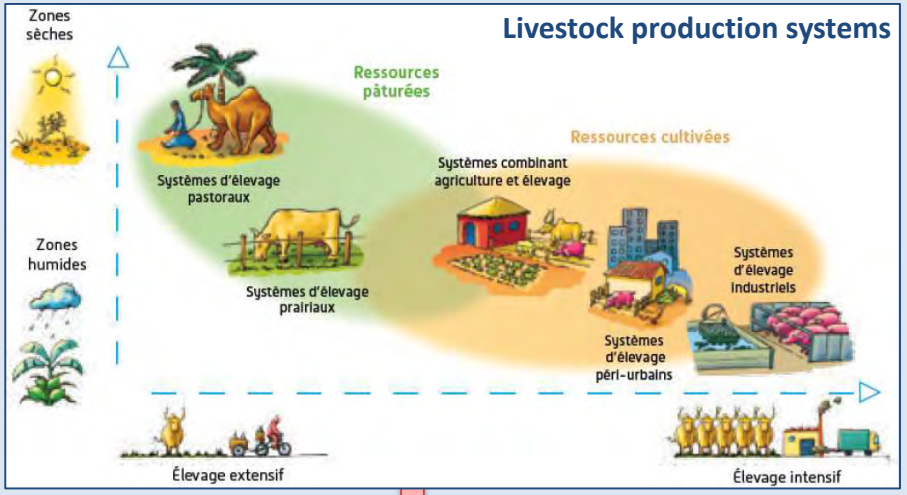
Source : Dorin (2011)





Production of PLANT food: + 186 %

Cereals, oilcakes, edible roots…



Meat, milk, eggs…

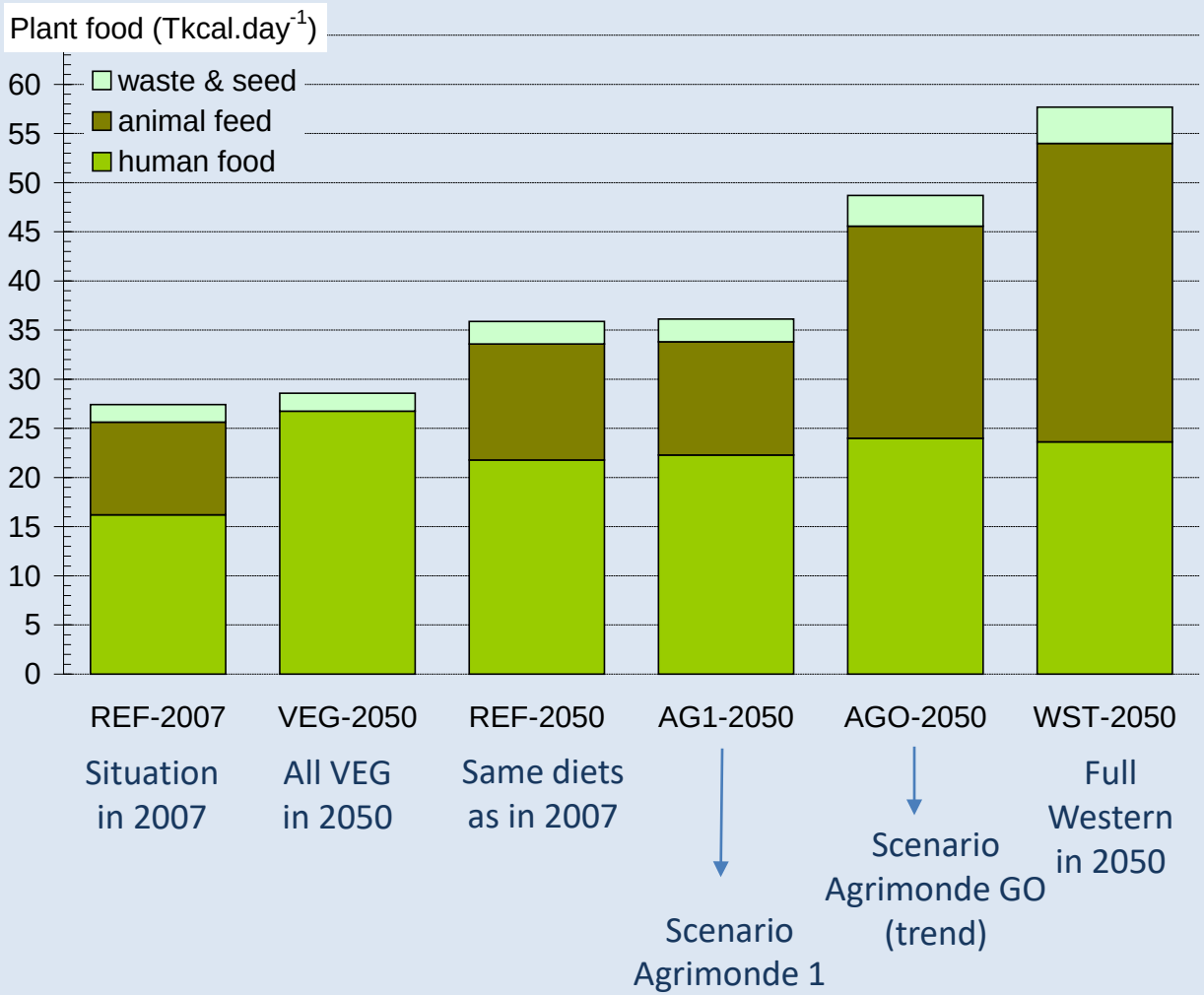
Production of ANIMAL foodstuffs: + 166 %

FEED for animals / animal FOOD ≈ 3

On world average,
we used
3 kcal or protein of PLANT food
to produce
1 kcal or protein of ANIMAL food

Global picture in 2050: according to 5 possible diet scenarios!

Consumption in Plant Food Product (PFP)



Economical & social issues

- economic growth ?
- income inequalities ?
- animal draft *vs.* tractors ?
- manure *vs.* chemical fertilizer ?
- wool, leather… ?
- cultural preferences, religious taboos ?
- …/…

Heath issues

(under- & over-consumption)

- proteins, lipids, iron, vitamin A… ?
- overweight, obesity ?
- cardiovascular diseases ?
- …/…

Environmental issues

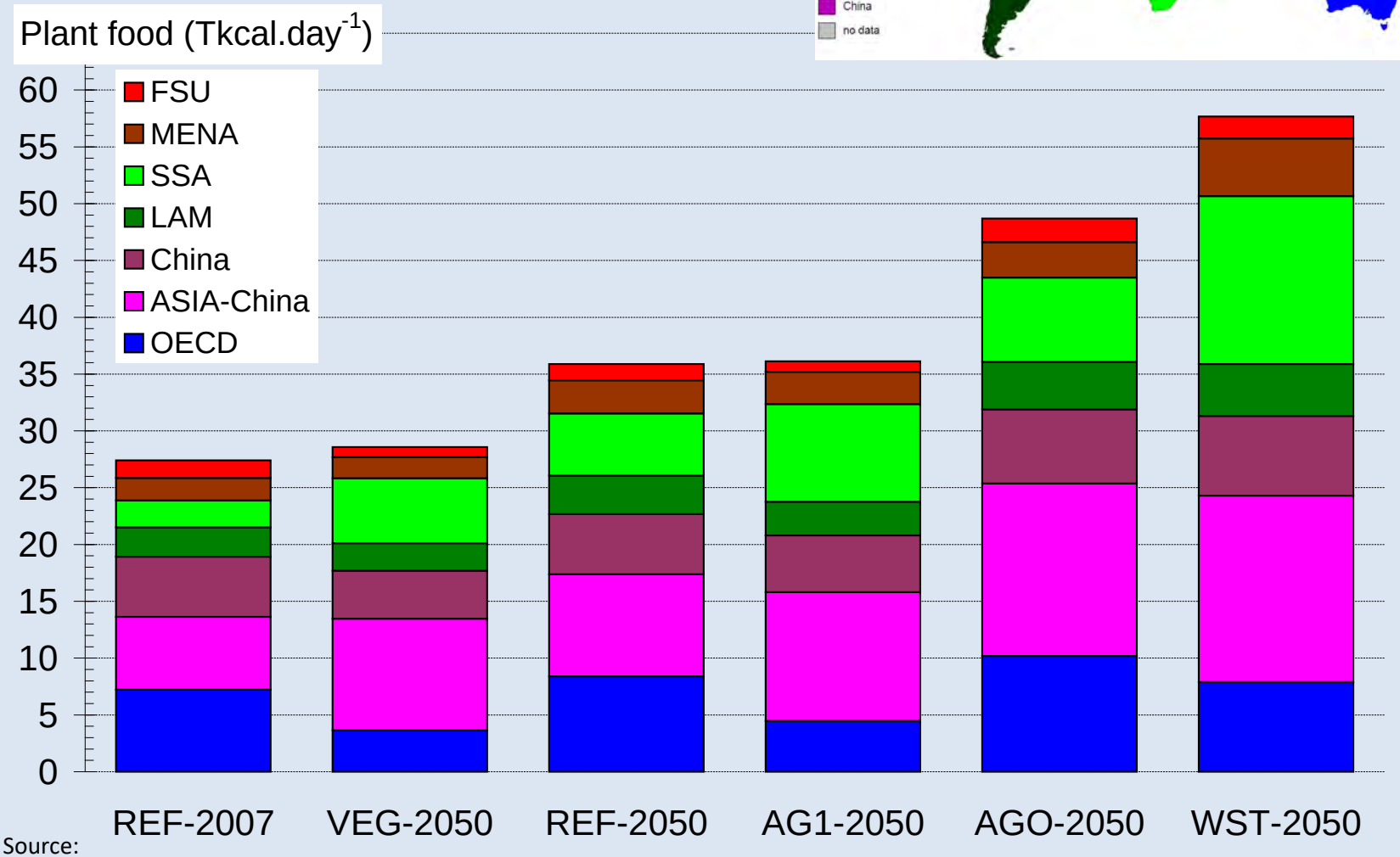
- deforestation (C, biodiversity) ?
- GHG (N_2O, CH_4, CO_2) ?
- fertilizers, freshwater, pesticides…
- …/…

Source:

- Dorin Bruno, Le Cotty Tristan, 2012. "Food Crops and Livestock. From Worldwide Past Evidences (1961-2007) to Open Scenarios (2050)", 12th Biennial Conference of the International Society for Ecological Economics, Rio de Janeiro, 16-19 June, 34 p.
- Le Cotty Tristan, Dorin Bruno, 2012. "A global foresight on food crop needs for livestock", Animal, 6:9, Sept., pp. 1528-36.
- Paillard Sandrine, Tréyer Sébastien, Dorin Bruno (Dir.), 2011 (2014: Springer). Agrimonde: scenarios and challenges for feeding the world in 2050, Quae, Versailles, 295 p.

Asia and Africa: the big players

Consumption in Plant Food Product (PFP)



Source:

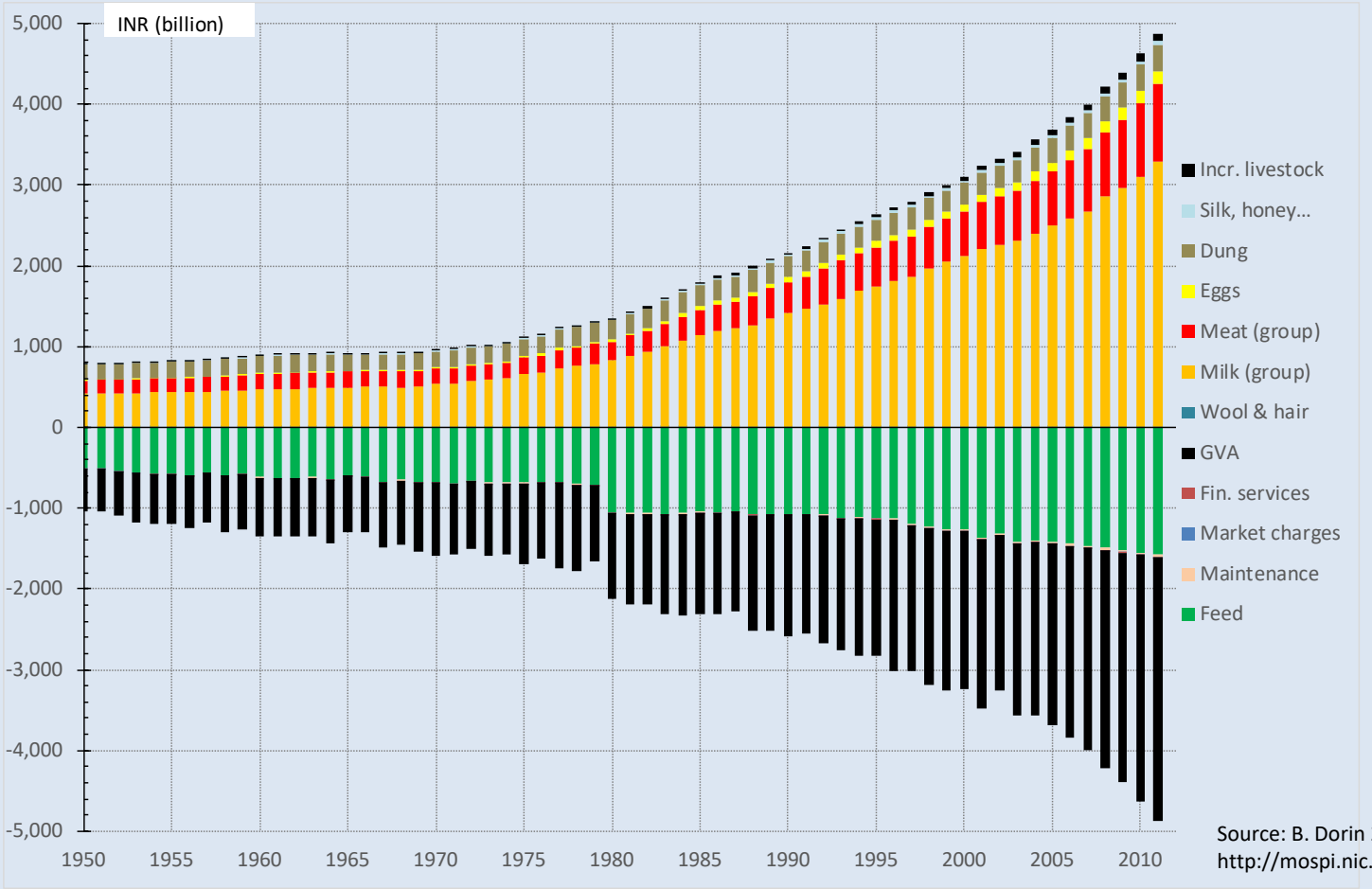
Dorin Bruno, Le Cotty Tristan, 2012. "Food Crops and Livestock. From Worldwide Past Evidences (1961-2007) to Open Scenarios (2050)", 12th Biennial Conference of the International Society for Ecological Economics, Rio de Janeiro, 16-19 June, 34 p.

❷ The big Indian puzzle

Contrasting trends…

- Vegetarianism as a value for upper classes (“sanskritization”)
- Land-shortage and high food-feed competition
  leading to a large use of by-products for animal feed (crops residues, food waste, forest…)
- But growing production and consumption of milk, meat …and feed

Output and Value Added from India livestock sector in constant 2011-12 prices (1950/51 – 2011-12)



Source: B. Dorin 2019, based on http://mospi.nic.in (05/11/2019)

Livestock feed: a big puzzle for data and models too!

(1) All global databases and models face difficulties and inconsistent results with India

Models
- IMAGE (PBL) – 8 regions (livestock)
- IMPACT (IFPRI) – 115 regions (?)
- GLOBIOM (IIASA) – 28 regions
- GLEAM (FAO) – 10 regions

Others (global databases, studies…)
- FAOSTAT
- Seré et Steinfeld, 1996
- Bouwman et al, 2004

(2) In India, many studies/papers use the same data/parameters (sometimes very old…) without checking their relevance or consistency

(3) …leading to large differences in results

Comparison of livestock feed availability estimates (circa 2000)

References	Region	Year	Concen-trates	Dry Fodders	Green Fodders	Total
Gorti et al (2012)	India	2000	26.9	274.5	149.5	450.9
NIANP (2003)	India	2000	31.6	340.9	125.6	498.1
Dikshit et Birthal (2010)	India	2003	42.6	419.3	189.2	651.0
GLOBIOM (Herrero et al 2013)	South Asia	2000	45.0	433.0	355.0	833.0
FAOSTAT (2019)	India	2000	36.9	-	-	-
USDA (2019)	India	2000	19.5	-	-	-

Notes: (1) data in million tonnes (Mt) of dry matter (DM); (2) when required, fresh matters (FM) have been converted into DM using 0.9 for concentrates and dry fodders, 0.25 for green fodders (NIANP, 2003); (3) By-products of sugarcane are classified in DF (e.g. NIANP, 2012) or GF (e.g. Gorti et al, 2012) ; (4) GLOBIOM estimates visually deduced from Herrero et al 2013

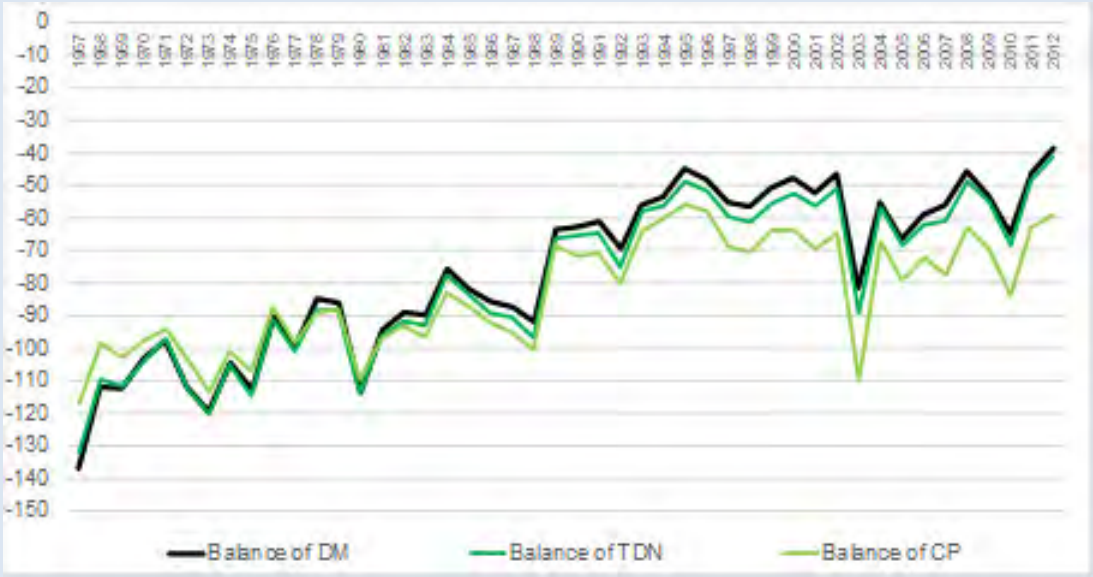
Our reference base for macro assessment and bio-modelling

NIANP 2003 & Gorti et al 2012

A feed balance database/model from States to All-India, from 1970 to 2025,
in different units: tons, Dry Matter (DM), Total Digestible Nutrients (TDN), Crude Protein (CP)
for 3 feed groups: Concentrates (C), Dry Fodder (DF), Green Fodder (GF)
and different animal species by age-classes

Concluding to a "feed deficit" between livestock feed availability and requirement

Our reproduction of the "feed deficit" using NIANP (2003) methodology



Simulations using the NIANP methodology show a feed deficit in dry matter (DM) which tends to decrease over time, but still accounted for 40% of the estimated needs in 2012.

Such a "feed deficit" is regularly mentioned in the literature on Indian livestock and feed, but few explanations are provided.

An apparent but unreal deficit shows some modelling gaps that need to be overcome:

- fixed and underestimated harvest/feed ratios over time?
- overestimation of animal body weights?
- overestimation of milk production ?
- ignorance of international trade?
- failure to properly take into account over time green fodders collected from borders of fields/roads, fallow lands and forests?
- etc.

Our basic objectives

- Balancing feed requirements and availabilities
- in DM, Energy, Proteins…
- State-wise
- from the 1960s to 2016
- for testing 2050 scenarios (on land use, trade, etc.)

Our basic methodological approach

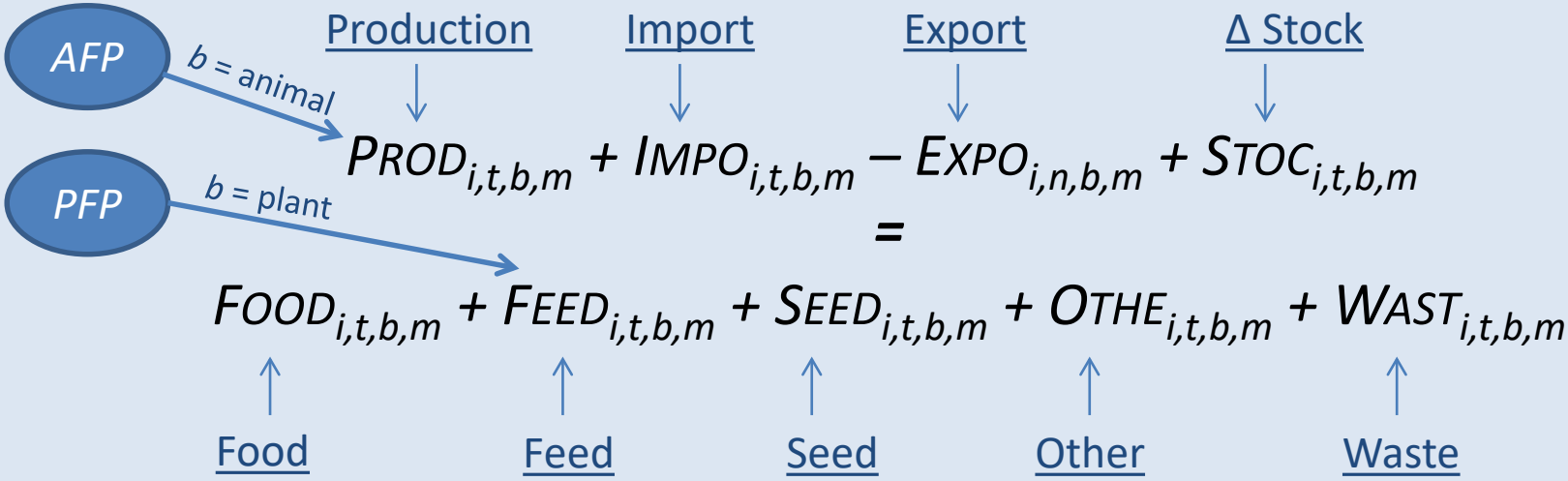
Building resource-and-use balances

… by Indian states (*i*)

… for every year (*t*) since the 1960s

… for 4 biomass compartments (*b*) : food plant, non-food plant, grazing animals, non-grazing animals

… in different units/metrics (*m*): GF, DF, calories, proteins, carbohydrates, fats



❸ Requirement of animal feed

General principles of assessment

(1) Livestock censuses heads
by Species, Sex, Race, Age, Activity

(2) Livestock production
(milk, eggs, meat…)

X

(3) Nutritional requirement
in DM, TDN, CP…
per head
and level of activity
(growth, breeding, milk, eggs…)

=

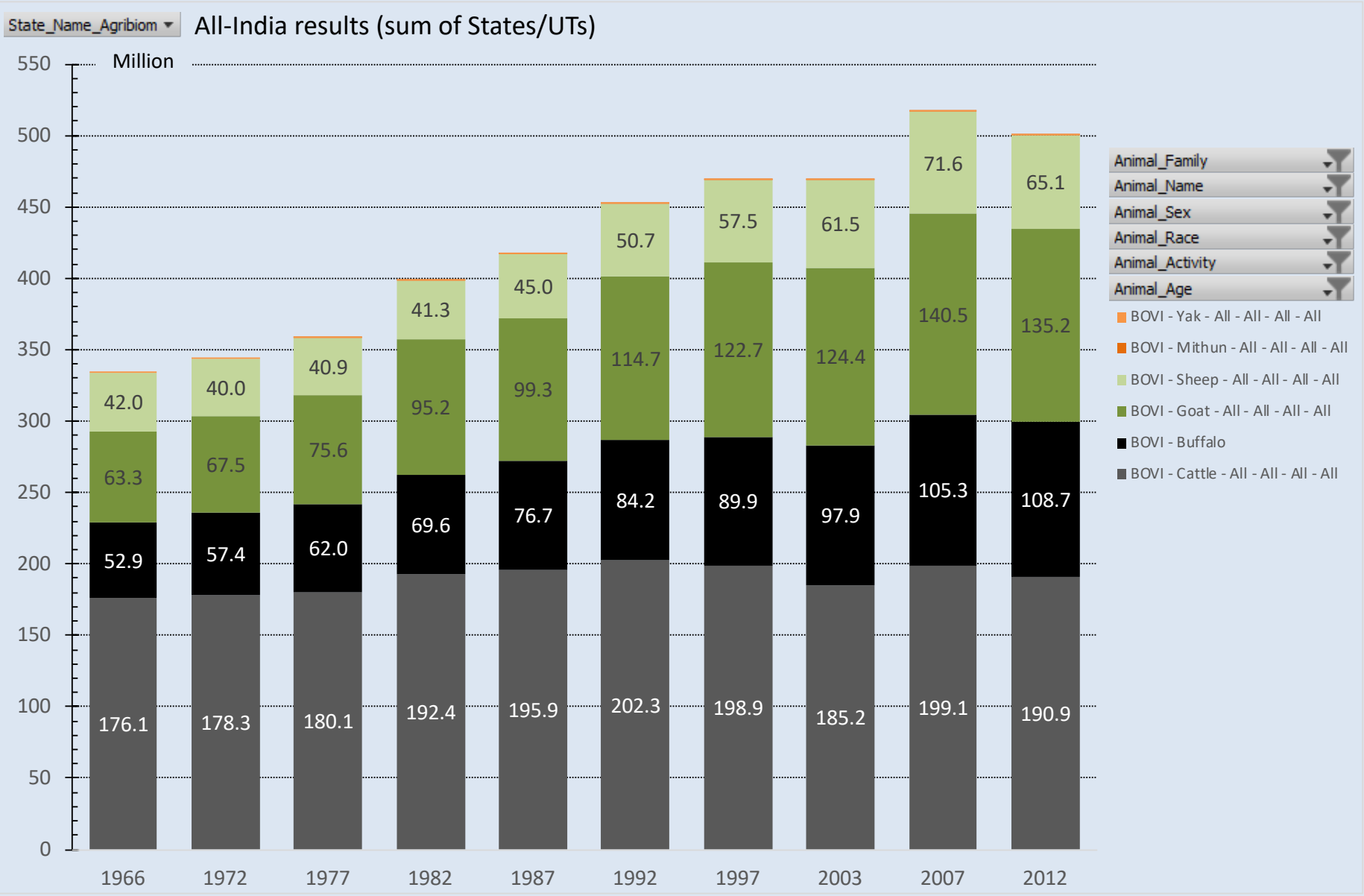
Tonnes
of feed
requirement
(DM, TDN, CP…)

ICAR, 2013. Nutrient Requirements of Cattle and Buffalo, etc., New Delhi (several booklets)

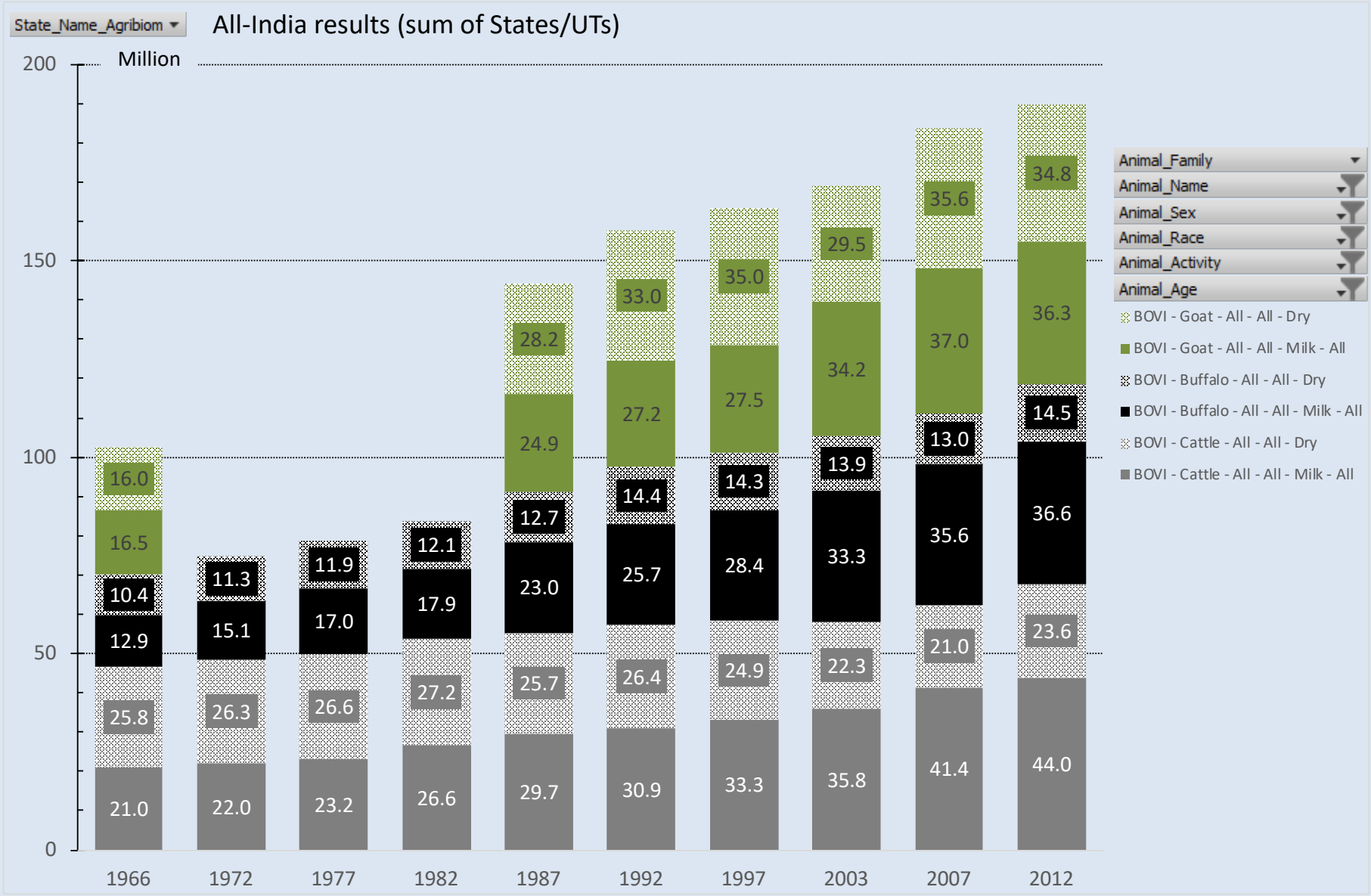
Livestock censuses (1966-2012)

- Several full-month time equivalent since 2016 to build and consolidate the database
  (entry of missing e-values, verification ∑ States = All-India, harmonization of categories, etc.)
- Grouping into 5 families: *BOVI*, *CAME*, *EQUI*, *GALI*, *SUID*
- Grouping into 16 species: *Buffalo, Camel, Cattle, Donkey, Duck, Fowl, Goat, Horse, Mithun, Mule, Pig, Pony, Quail, Sheep, Turkey, Yak*
- Grouping into 3 sexes: *Female, Male, Anonym*
- Grouping into 3 races: *Domestic, Improved, Anonym*
- Grouping into 9 activities: *Dry, Egg, Growth, Milk, Meat, Not calved, Other, Work (Breeding, Breeding+Draught, Cart, Castrated, Draught, Non_Castrated, Sport…), Anomym*
- Grouping into 18 age classes (varying according to species)
- Calculation or verification of totals and sub-totals
  for 10 years x 31 States/UTs (average 1966-2012) x 583 categories (average/state) ≈ 180,700 values
- Interpolation to get values for the years between each census ≈ **831,200 values in total**

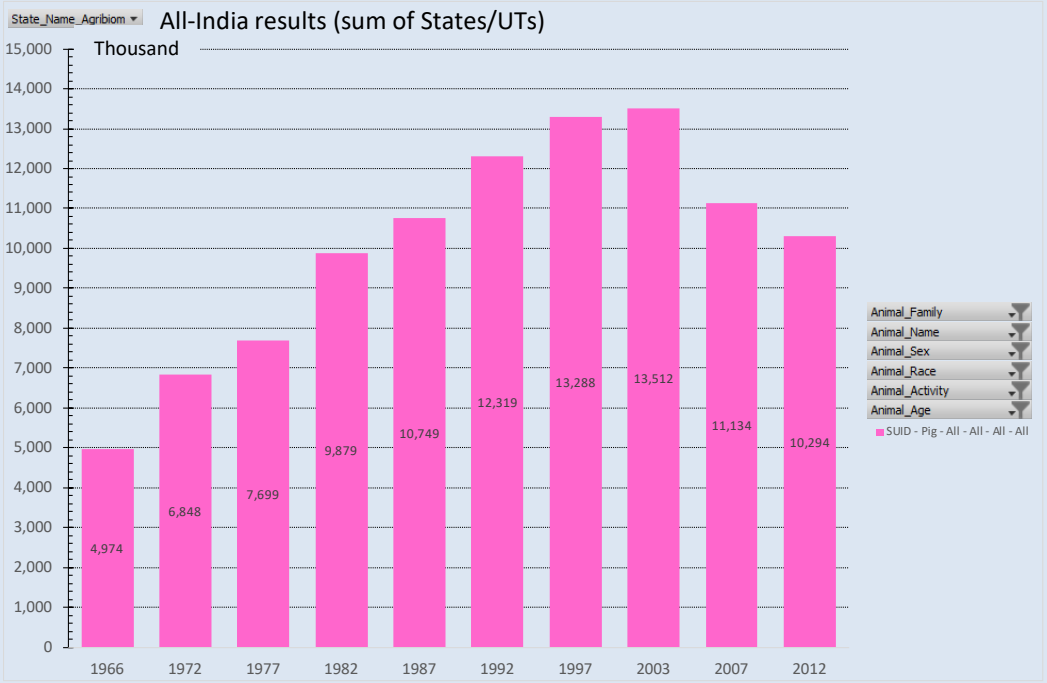
Heads of BOVIDE (and main species) from 10th to 19th census (1966-2012)



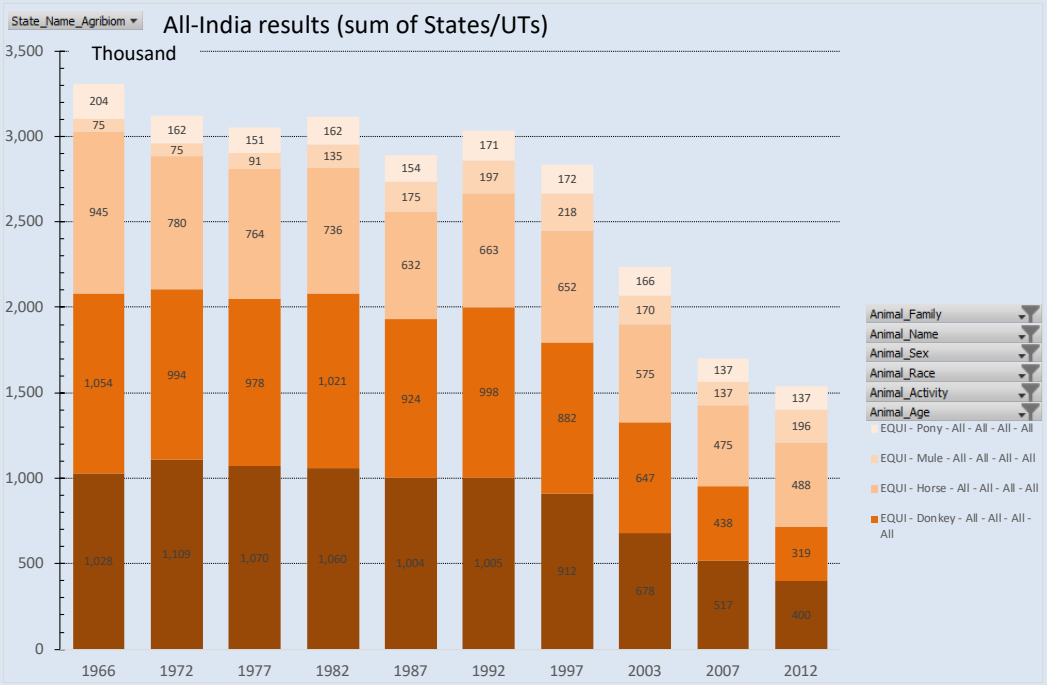
Heads of Milk-BOVIDE from 10th to 19th census (1966-2012)



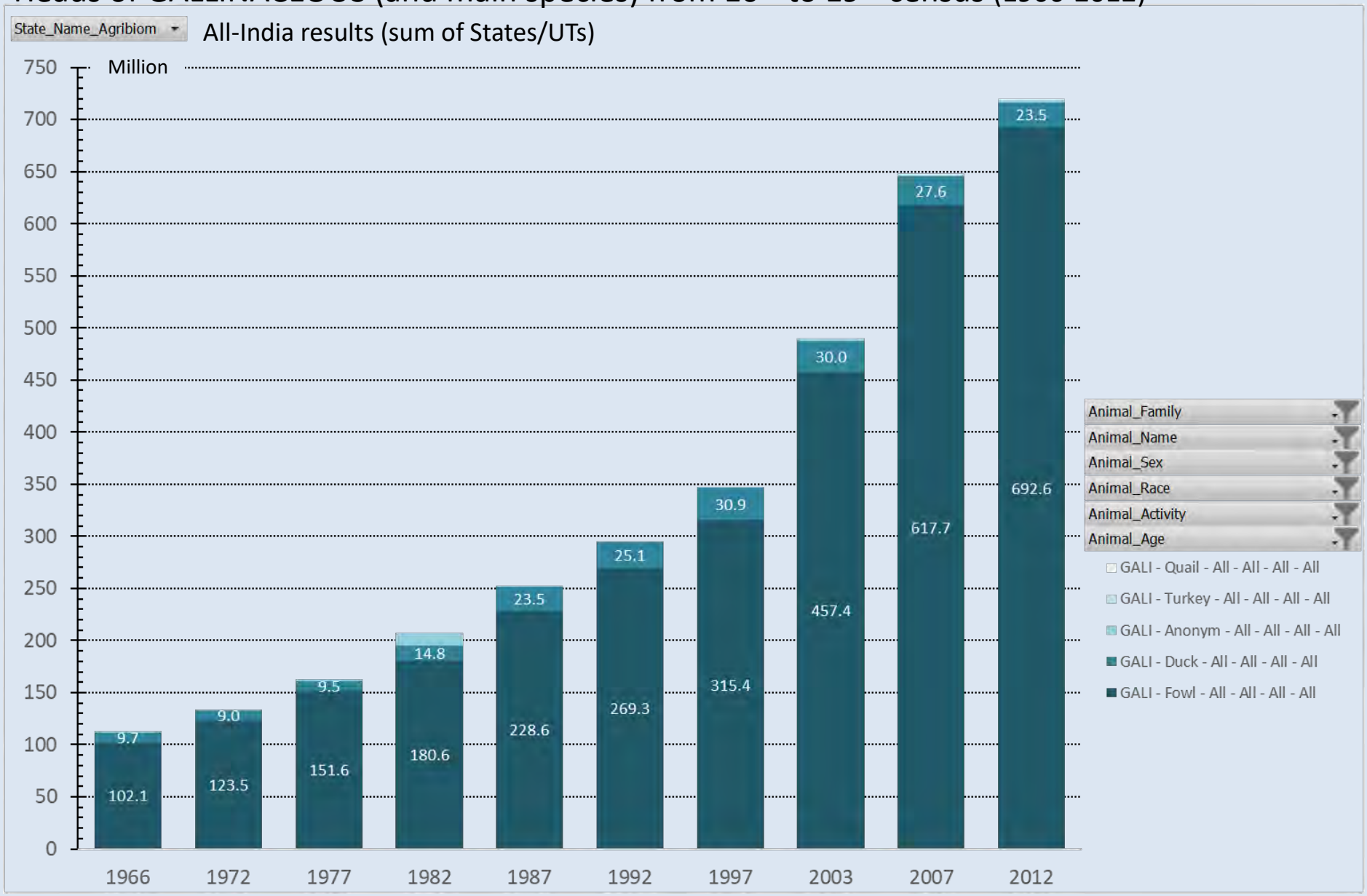
Heads of SWINE
from 10th to 19th census
(1966-2012)



Heads of CAMELID & EQUINE
(and main species)
from 10th to 19th census
(1966-2012)

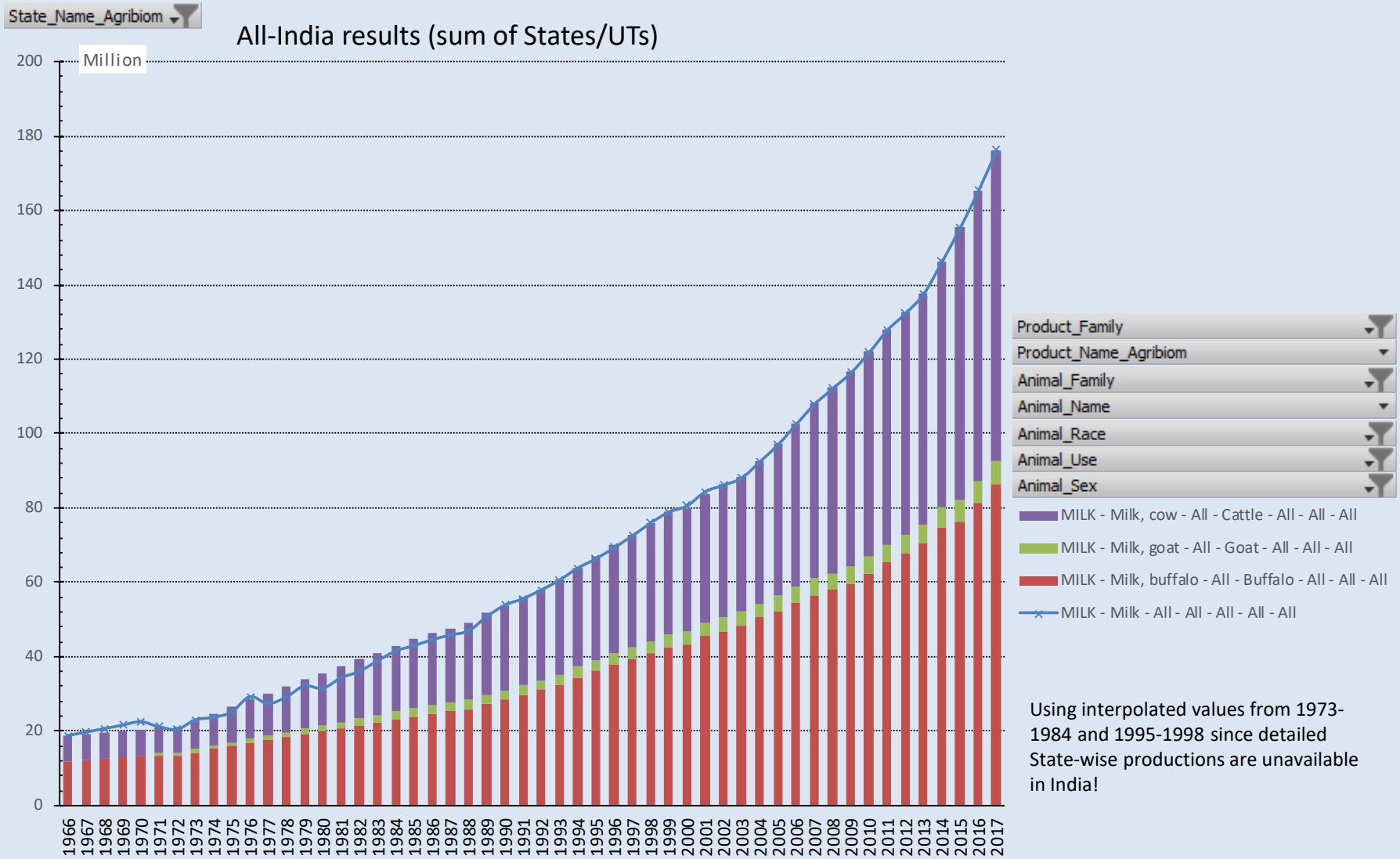


Heads of GALLINACEOUS (and main species) from 10th to 19th census (1966-2012)



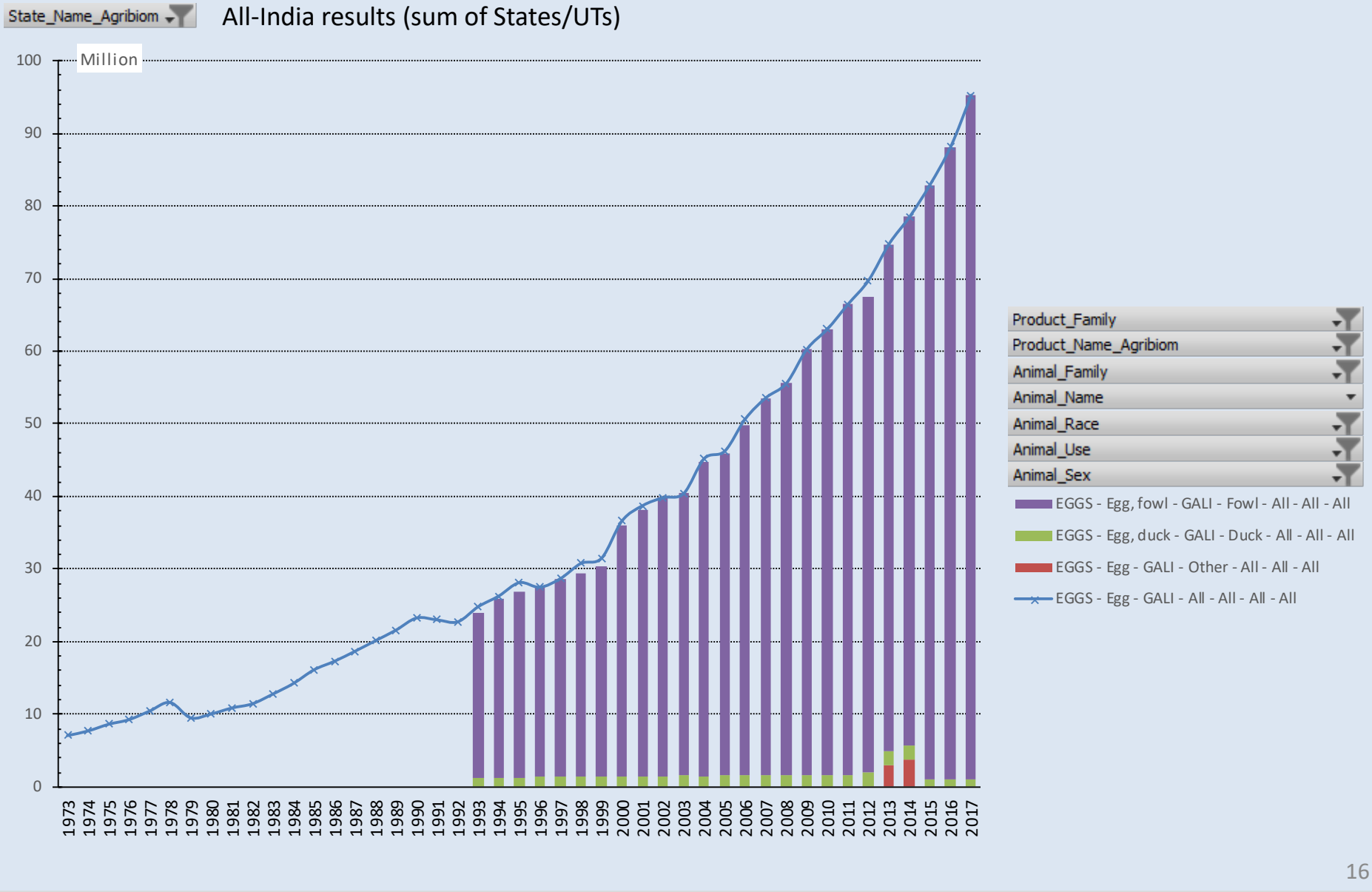
Livestock productions

Production (tonnes) of MILK (1966-2017)

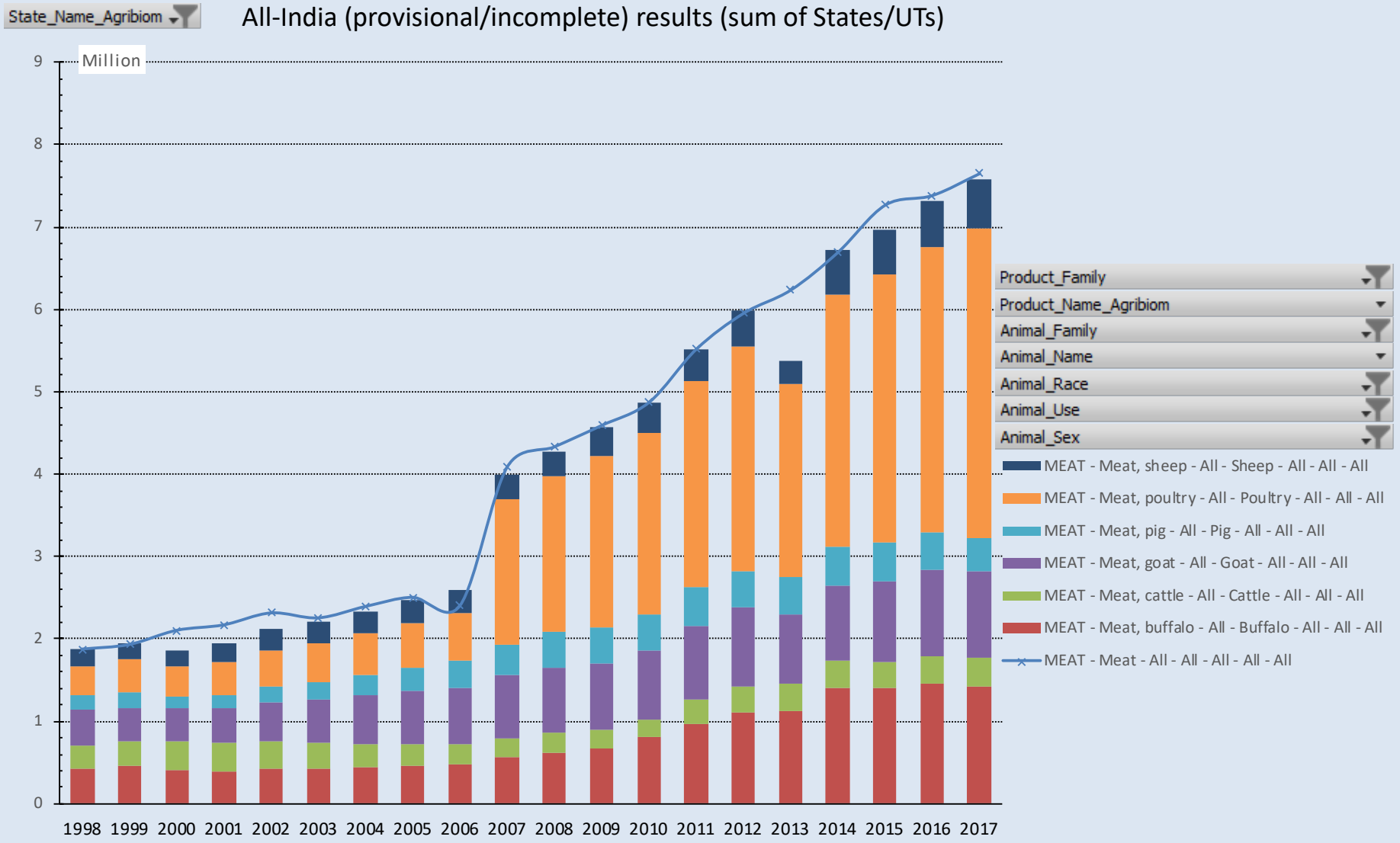


Using interpolated values from 1973-1984 and 1995-1998 since detailed State-wise productions are unavailable in India!

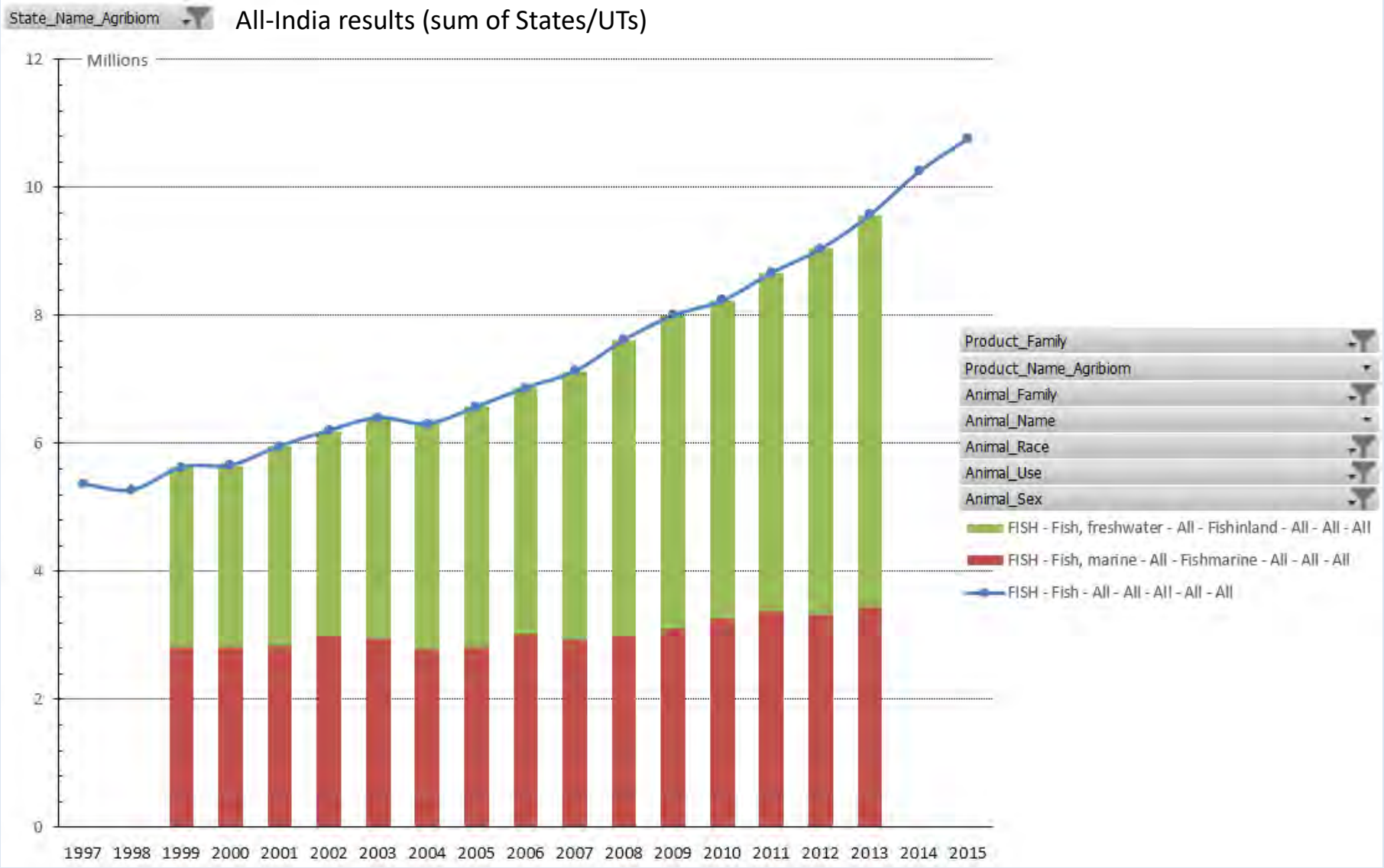
Production (1000 units) of EGGS (1973-2017)



Production (tonnes) of MEAT (1998-2017)



Production (tonnes) of FISH (1997-2015)



❹ Availability in animal feed

General principles of assessment

Crop production (paddy, wheat, etc.)
in tons
state-wise (GOI)

Land use
in ha
state-wise (GOI)

Harvest rates, Feed ratios…
(Gorti et al 2012, FAO…)

Crop production	Harvest Index		Extraction Rate	
	Crop residues	Oilcakes	Grains	Bran/husk
Paddy	1.3	-	0.02	0.08
Wheat	1.0	-	0.02	0.08
Sorghum	2.5	-	0.05	-
Pearl millet	2.5	-	0.05	-
Barley	1.3	-	0.10	-
Maize	2.5	-	0.10	-
Finger millet	2.0	-	0.05	-
Small millets	2.5	-	0.10	-
Other cereals	2.0	-	0.10	-
Total Pulses	1.7	-	-	0.03
Groundnut	2.0	0.70	-	-
Sesamum indicum seeds	-	0.70	-	-
Rape & mustard	-	0.70	-	-
Linseed	-	0.70	-	-
Niger	-	0.70	-	-
Sunflower	-	0.70	-	-
Safflower	-	0.70	-	-
Soybean	-	0.70	-	-
Sugarcane	0.25	-	-	-
Coconut	-	0.0625	-	-
Cotton	-	0.0499	-	-

Land use category	Green fodder (tonnes/ha/year)
Gross cropped area	1.6
Forests	1.5
Permanent pastures	5.0
Cultivable waste lands	1.0
Current fallows	1.0
Other fallows	1.0
Miscellaneous tree crops	1.0

Concentrates (CO)
Dry fodders (DF)

Green fodders (GF)

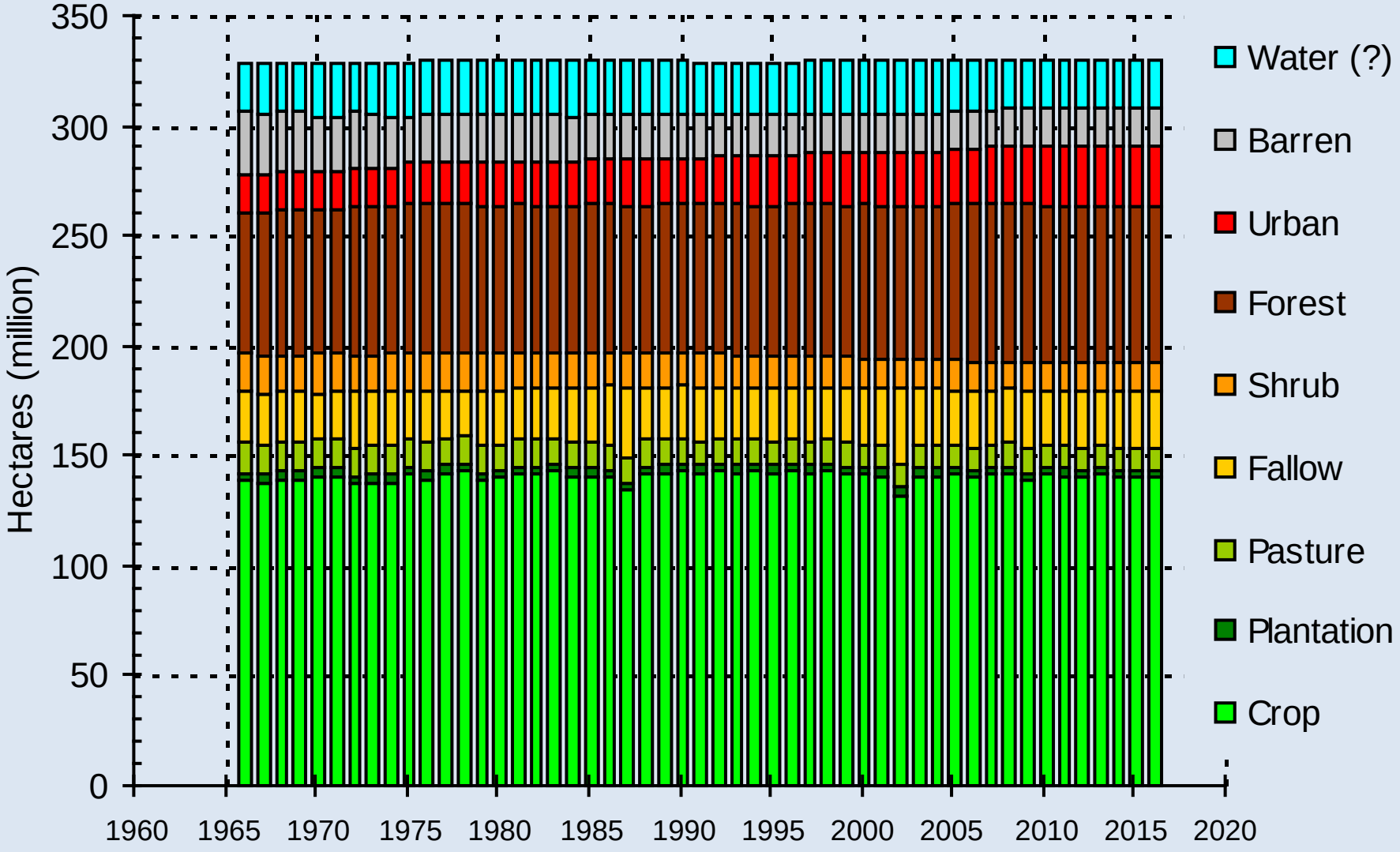
Nutritional contents
(ICAR 2013…)

Tonnes of feed availability
(DM, TDN, CP, kcal…)

Land use

All-India results (sum of States/UTs)

Note: 2015 and 2016 values are a strict copies of 2014 values since Indian land-use statistics are not updated since 2014.



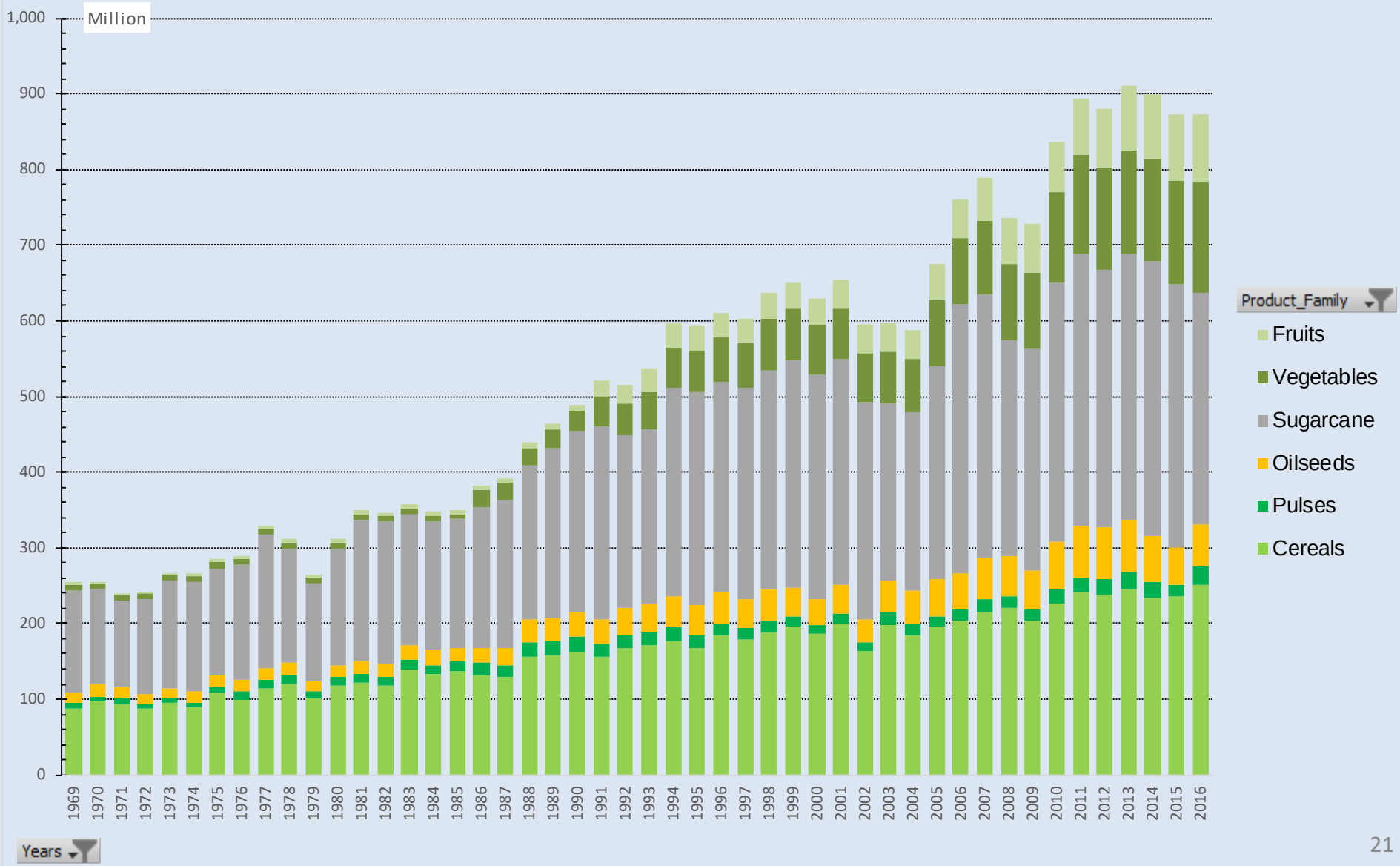
Crop productions (excluding spices and condiments)

Production (tonnes) of annual and perennial crops (1969-2016)

Provisional results, in particular for fruit and vegetables for which data by crop are only available from 1991 onwards, with a few exceptions

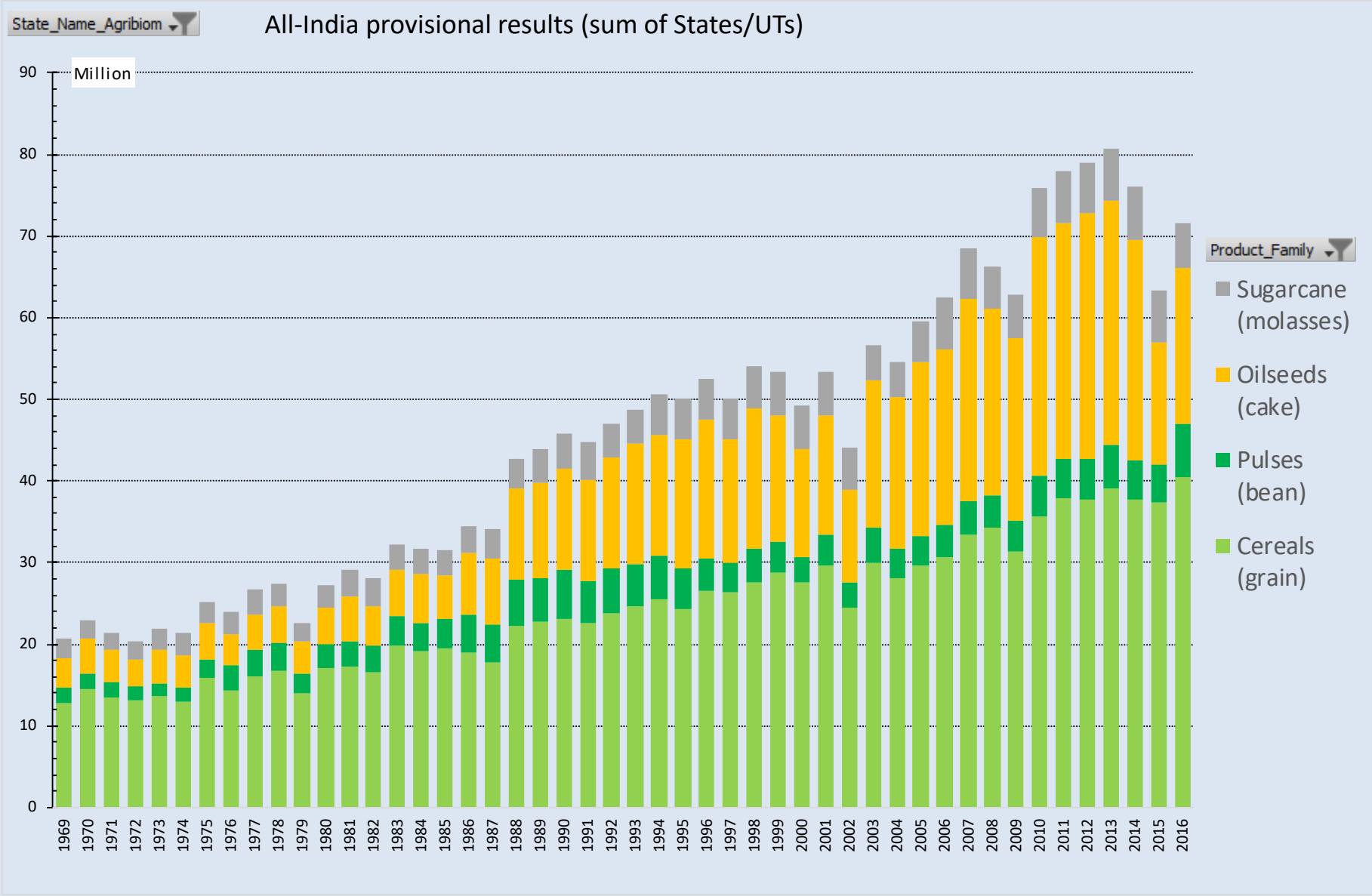
Product_Name_Agribiom | State_Name_Agribiom

All-India results (sum of States/UTs)

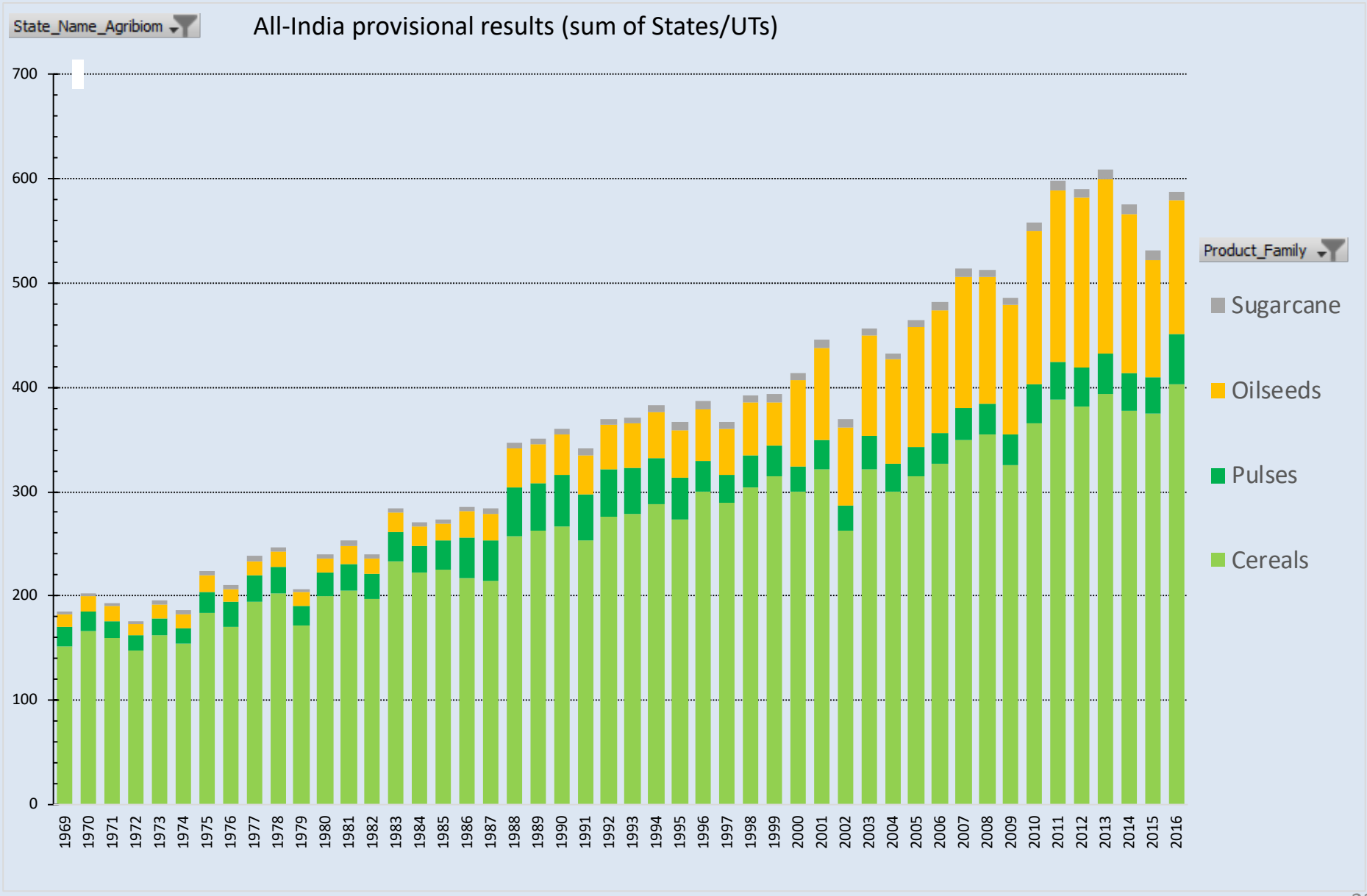


Availability of feed (excluding fruits, vegetables, spices, condiments)

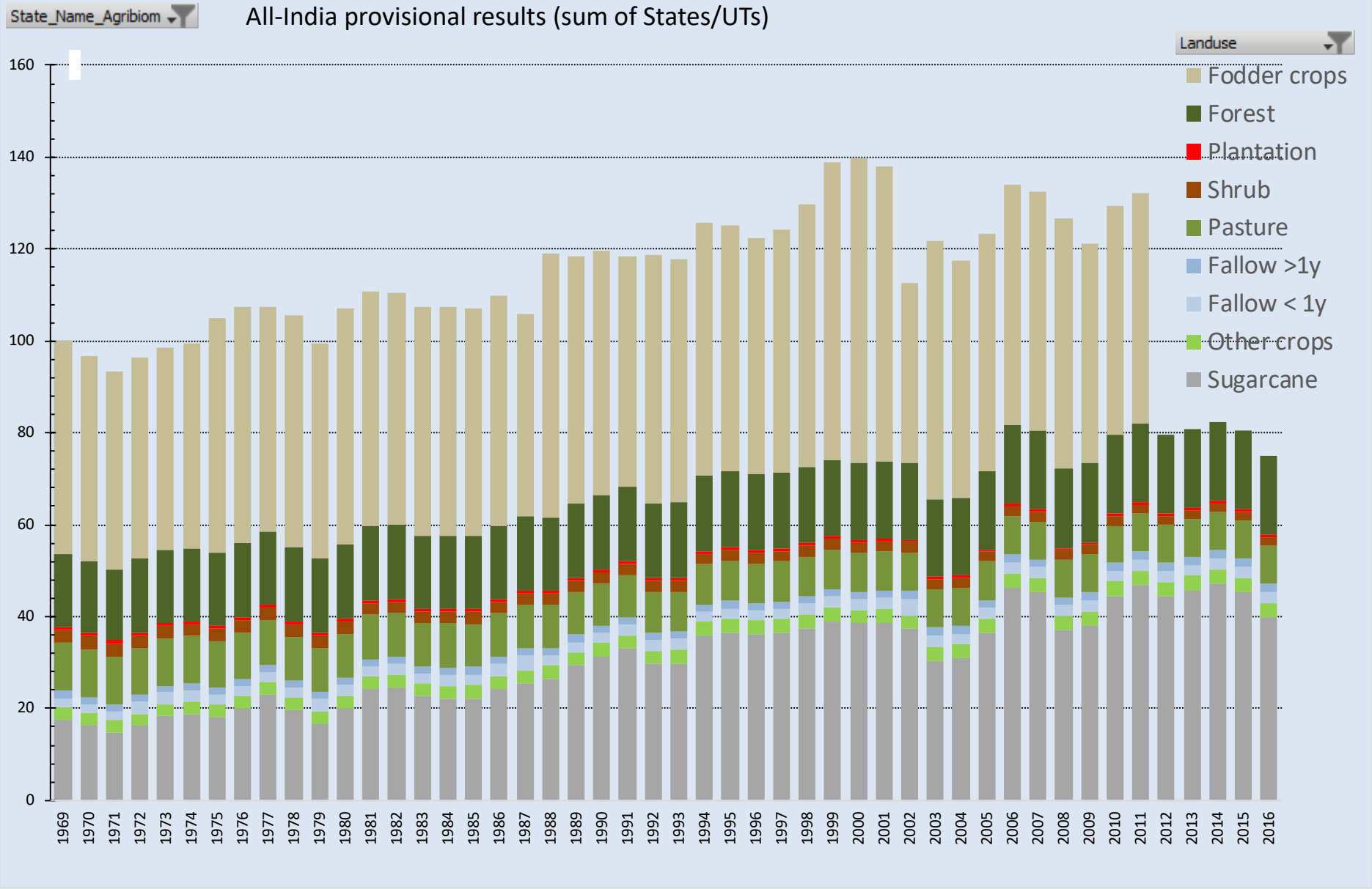
CONCENTRATES (tonnes) in DM_{eq} (1969-2016)



DRY FODDERS (tonnes) in DM_{eq} (1969-2016)

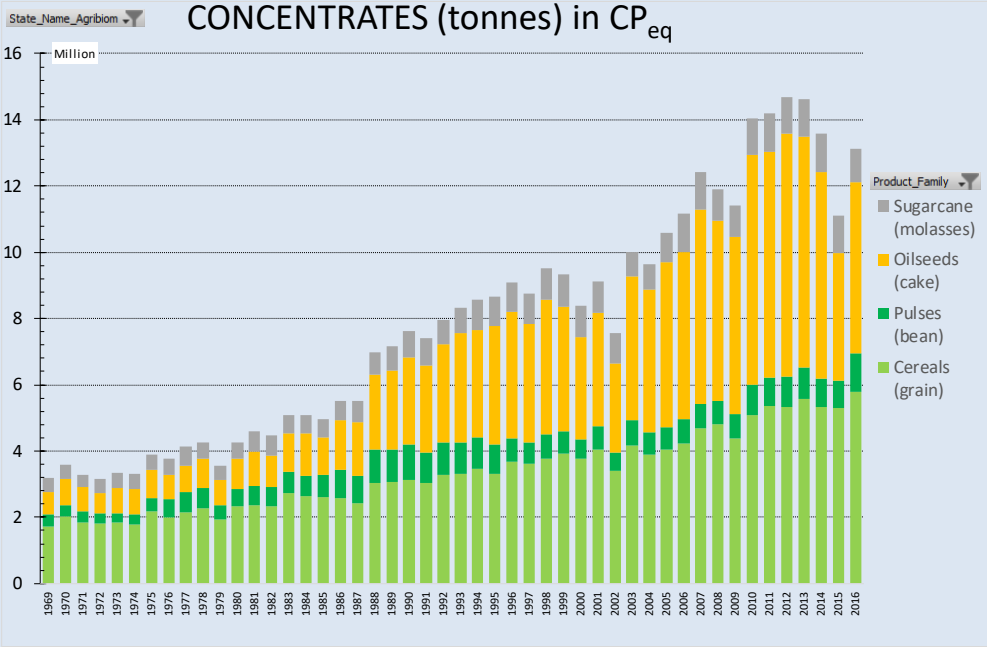


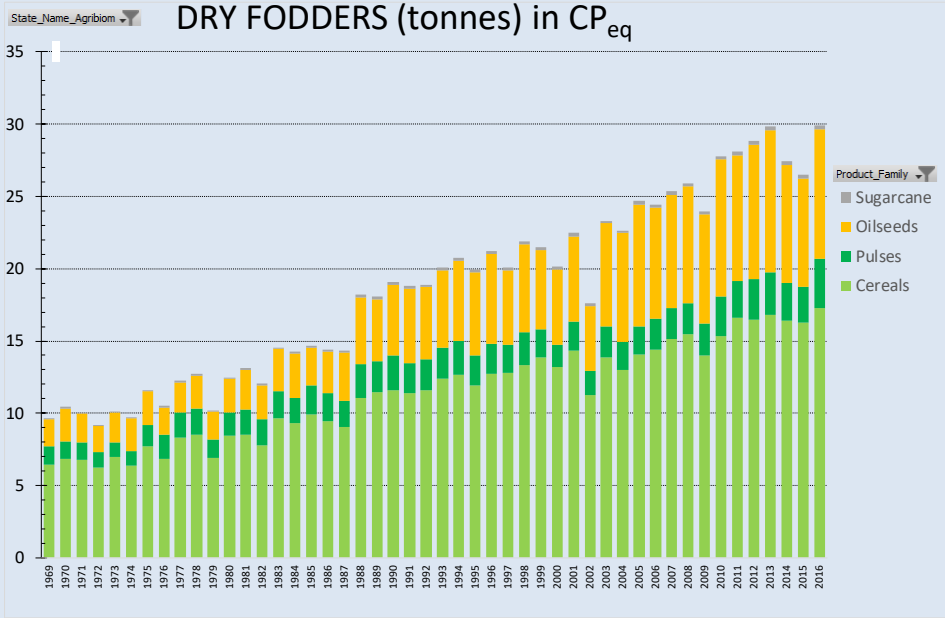
GREEN FODDERS (tonnes) in DM_{eq} (1969-2016)

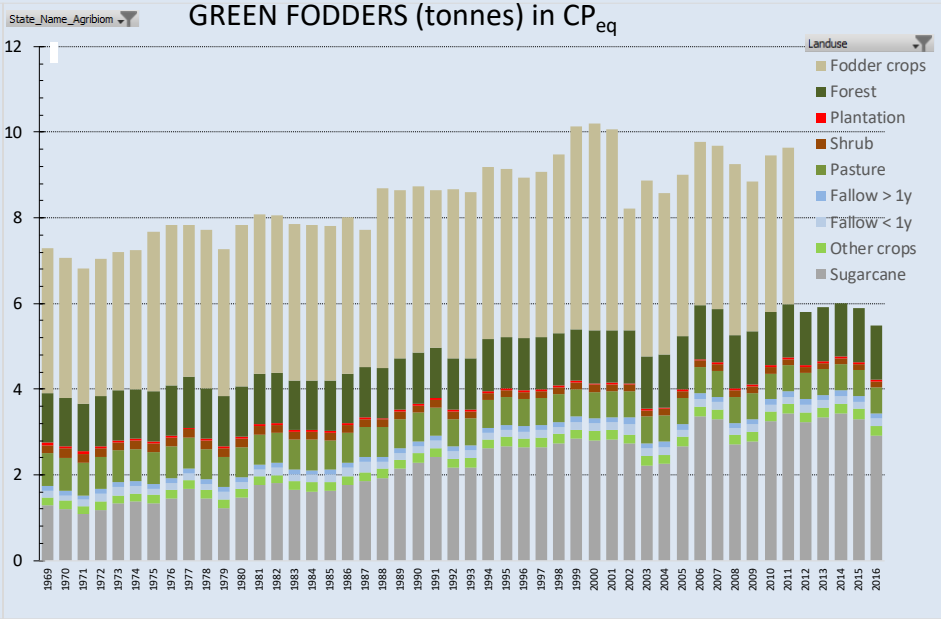


FEEDS in Protein$_{eq}$ (1969-2016)

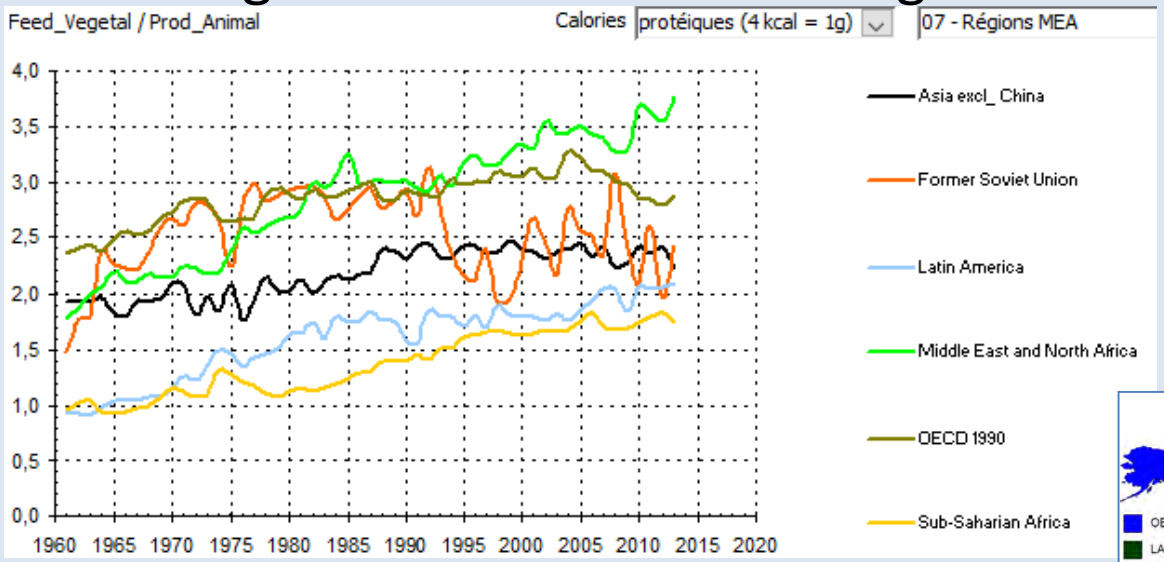
All-India provisional results (sum of States/UTs)







Coming back to the world average

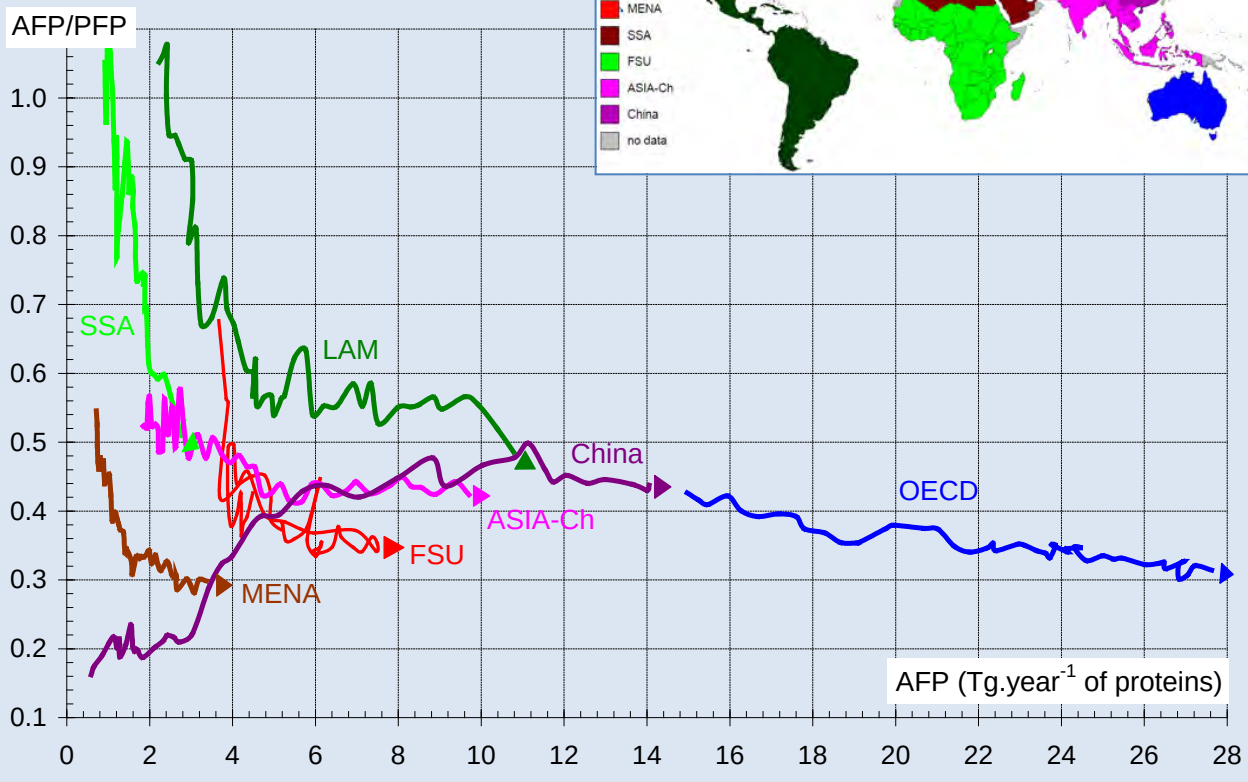


PLANT Food / ANIMAL FOOD ≈ 3

Cereals, Oilcakes… *Meat, Milk…*

Declining productivities of plant feed…

ANIMAL Food Production / PLANT Food Production



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