The Eradication of Rinderpest – Was It (Really) Worth It?

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Outline

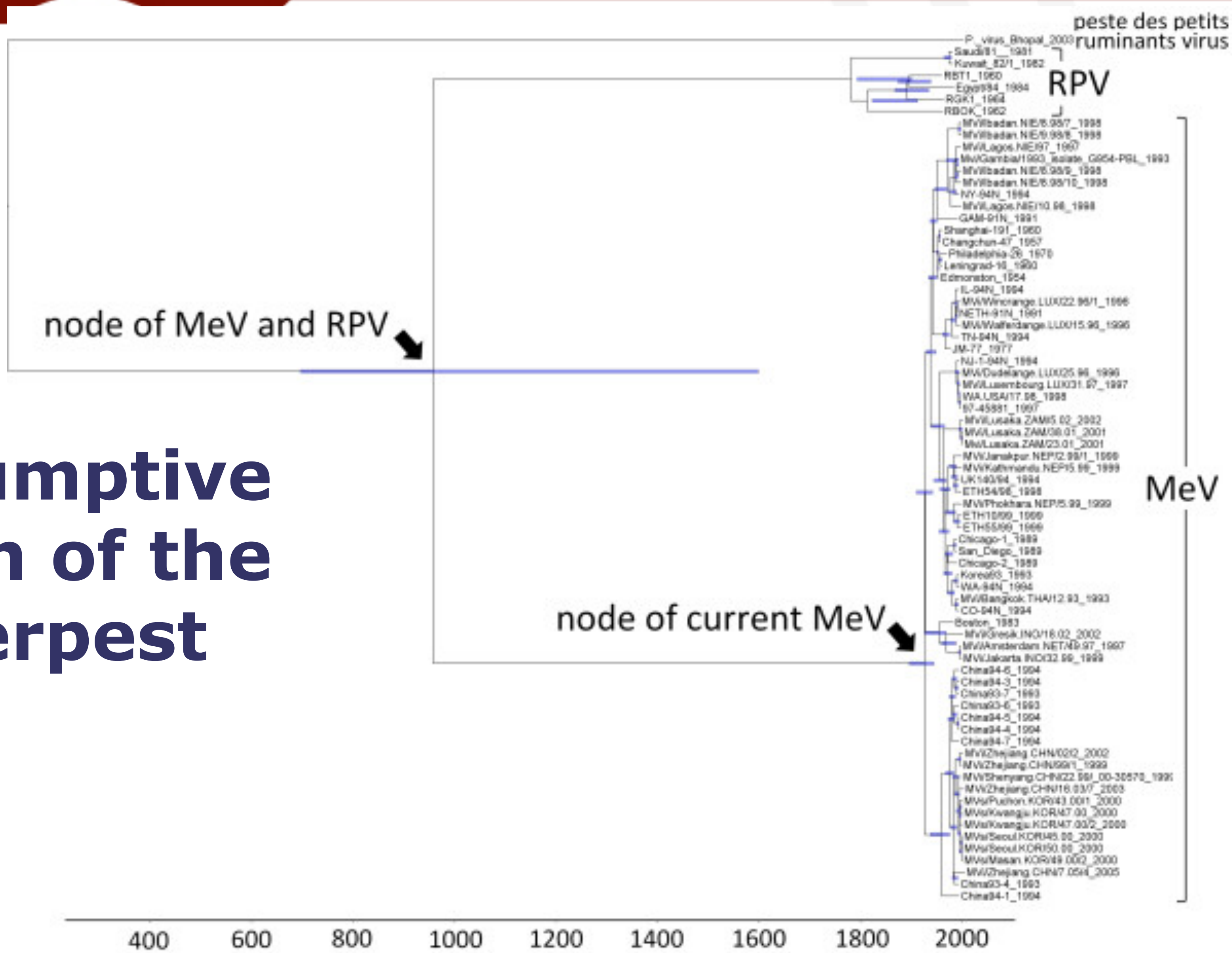
- History of rinderpest (RP) and its control / eradication
- Post WWII 'cost' of RP eradication
- Direct impact of 'endemic' RP (mortality and morbidity)
- Estimated benefits of RP control and cost-benefit ratios
- CBA of RP eradication: Chad case study (ver 1.0)
- Conclusions, next steps, afterthoughts, and discussion

Caveat

"Cost-benefit analyses of eradication programmes involve biases that tend to underestimate the costs and overestimate the benefits"

Judith Myers et al., 1998

Presumptive Origin of the Rinderpest Virus



RP History, 18th & 19th Century

- **1711**: RP spread through Western Europe
- **1714**: *Giovanni Lancisi* (personal physician of pope Clement XI) recommends: slaughter and deep burial of infected and exposed animals accompanied by movement control to be enforced by drastic ‘penalties for offenders’ (death!).
- *Thomas Bates*, Surgeon of His Majesty’s Household in London, introduced the Lancisi measures to England with ‘compensation of cattle owners’.

RP History, 18th & 19th Century

- **1762**: The world's first vet school opened in Lyons to teach Lancisi's principles of rinderpest control.
- **1857 – 1866**: RP again spread through Europe.
- **1868**: Indian Cattle Plague Commission appointed by GoI.
- **1880s**: Veterinary schools and government vet departments were established in Europe.
- **1887 – 1893**: RP spread through sub-Saharan Africa, introduced through port of Massaua

RP History, 20th Century

- *E. Semmer* discovered the protective powers of serum from recovered animals. This led to the development of serum-virus methods of immunization which became a standard prophylactic procedure until the 1930s.
- **1920s**: *J.T. Edwards* attenuated rinderpest virus by growing it serially (600 passages) in goats (GTRV – Goat tissue rinderpest vaccine). The attenuated virus immunized for life.
- **1924**: OIE was created as an inter-governmental effort to combat rinderpest (RP introduction into Belgium).

RP History, 20th Century

- **1950**: The Inter-African Bureau of Epizootic Diseases was founded with a directorial plan to eliminate rinderpest from Africa.
- **1950s**: It became easy to grow specific cells in tissue culture and propagate viruses therein.
- **1957**: *W. Plowright* and *R. Ferris* grew rinderpest virus in cultures of calf kidney cells.
  - The virus was stable, attenuated, and non-infectious by the 90th serial passage.
  - The vaccine was **cheap** to produce and easy to assay for potency and safety. It quickly became the vaccine of choice.

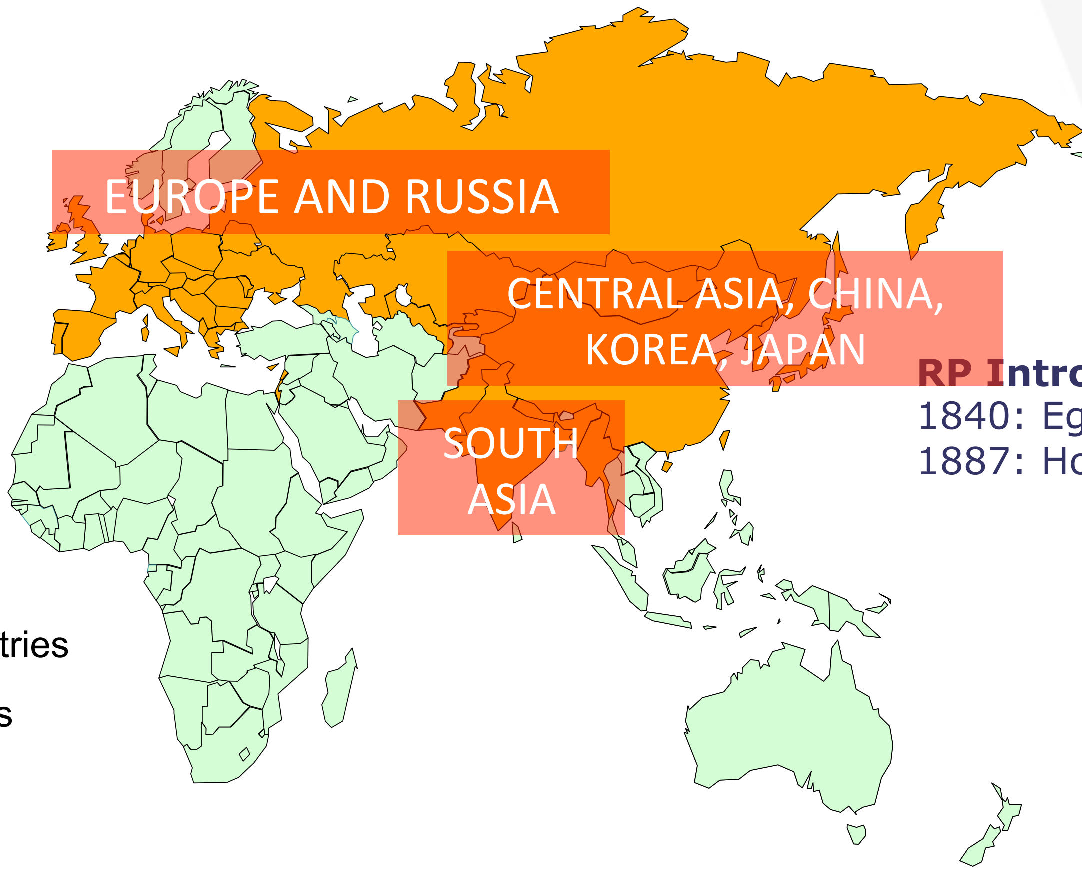
RP History, 20th Century

- **Early 1950s**: China embarks on national rinderpest eradication programme (±50 million bovines)
- **1954**: India launched the national rinderpest eradication programme (±200 million bovines).
- **From 1960s**: Regional eradication efforts based on 'institutionalized mass vaccination' and international funding (JP15, PARC, WAREC, etc.)
- **1990s**: Targeted approaches to eliminate residual 'pockets of infection' (CAHWs etc).

Evolution of RP Control

- **18th & 19th century**: Stamping out and movement control.
- **Early 20th century (until 1930):** Movement control and application of serum to bovines to limit spread of outbreaks.
- **1930s to late 1950s:** In response to outbreaks, movement control and *reactive vaccination*, and *protective vaccination* along borders (buffers) and in high risk areas.
- **1950s / early 1960s**: Eradication programmes based on *mass vaccination.*

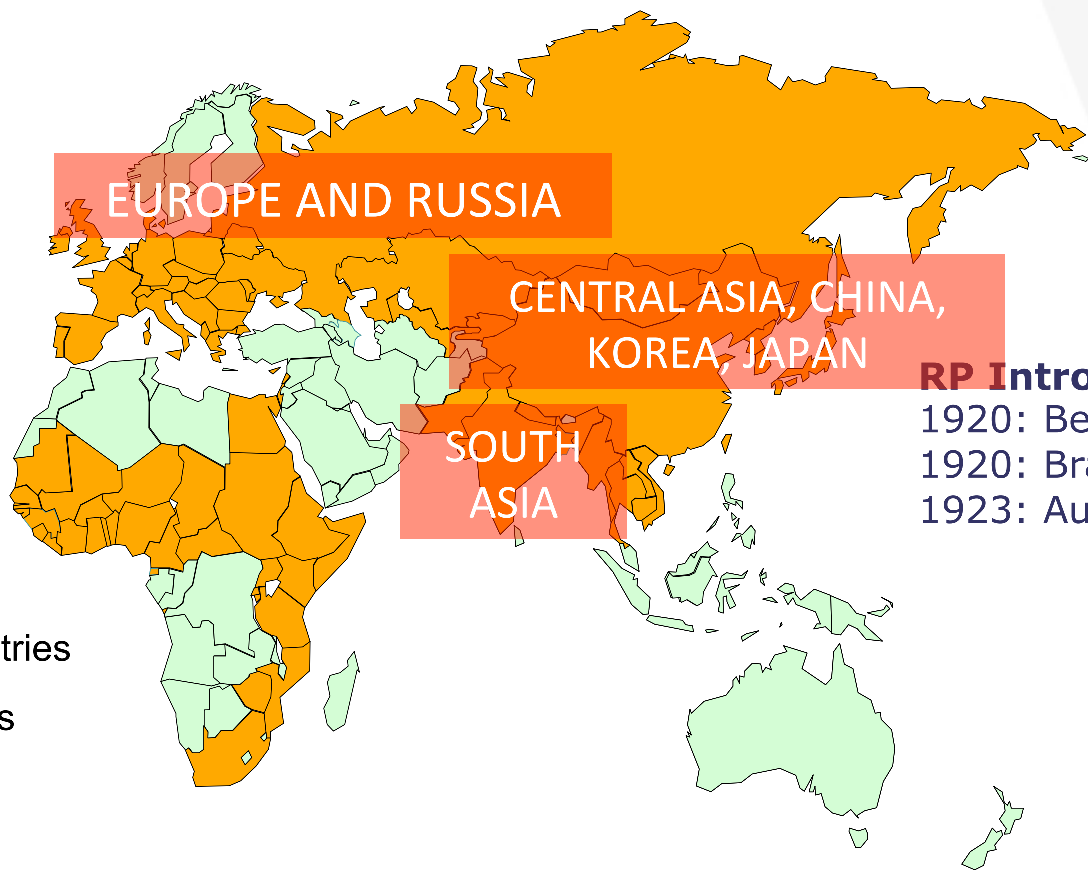
Rinderpest Occurrence 1800



RP Introductions
1840: Egypt
1887: Horn of Africa

Infected countries
Free countries

Rinderpest Occurrence 1900

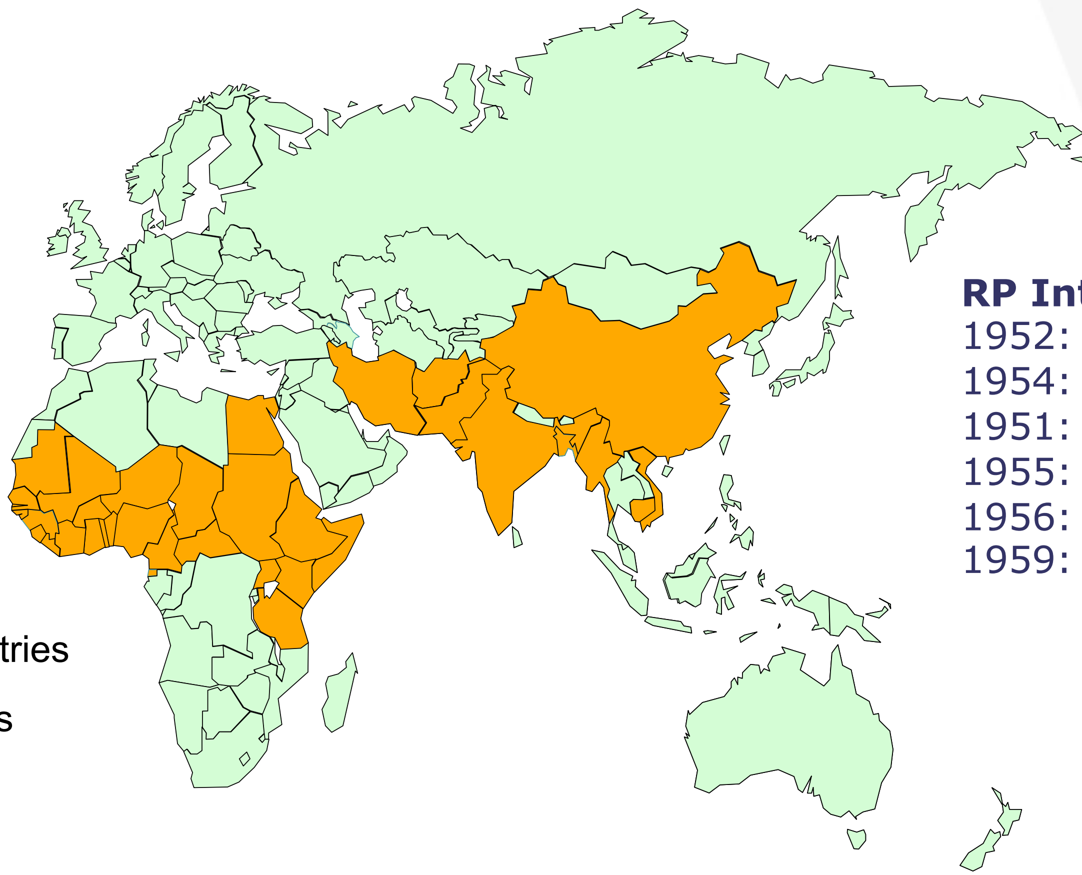


Infected countries

Free countries

RP Introductions
1920: Belgium
1920: Brazil
1923: Australia

Rinderpest Occurrence 1950



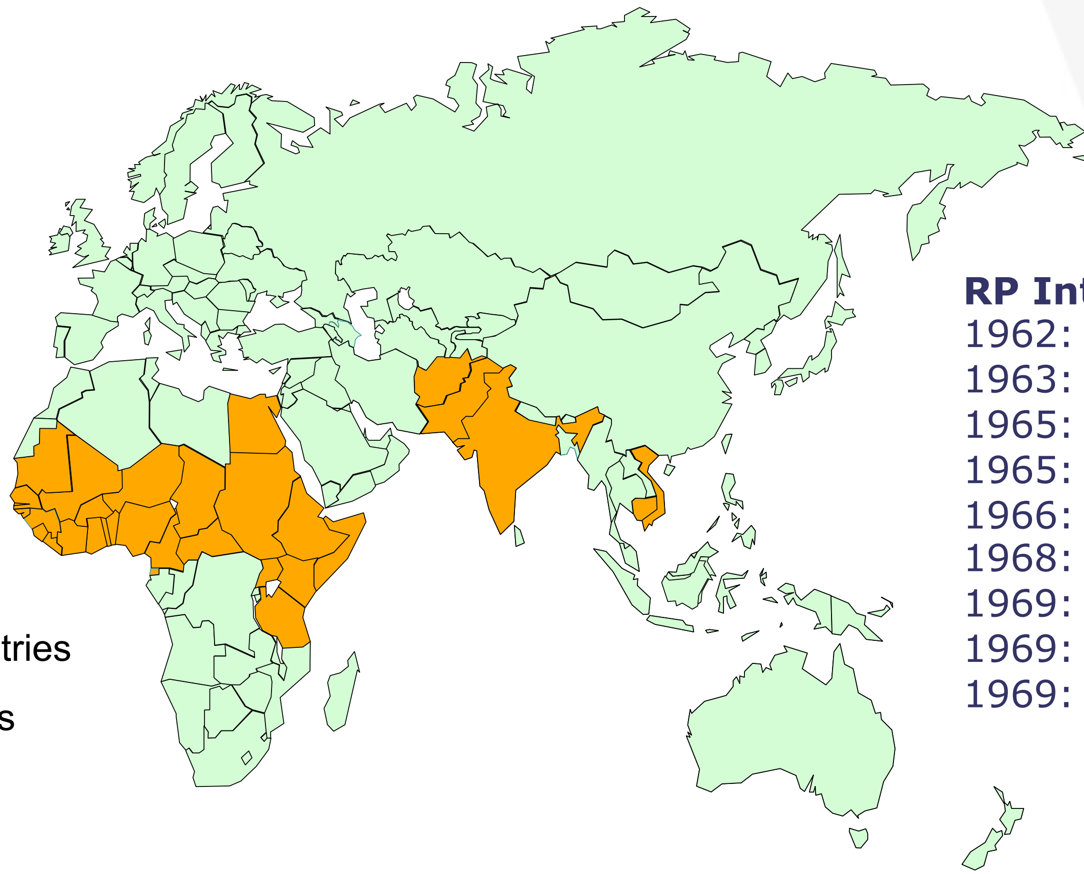
Infected countries

Free countries

RP Introductions
1952: Nepal
1954: Italy
1951: Thailand
1955: Philippines
1956: Thailand
1959: Malaya

Rinderpest Occurrence 1960

140 (?) million vaccinations later……



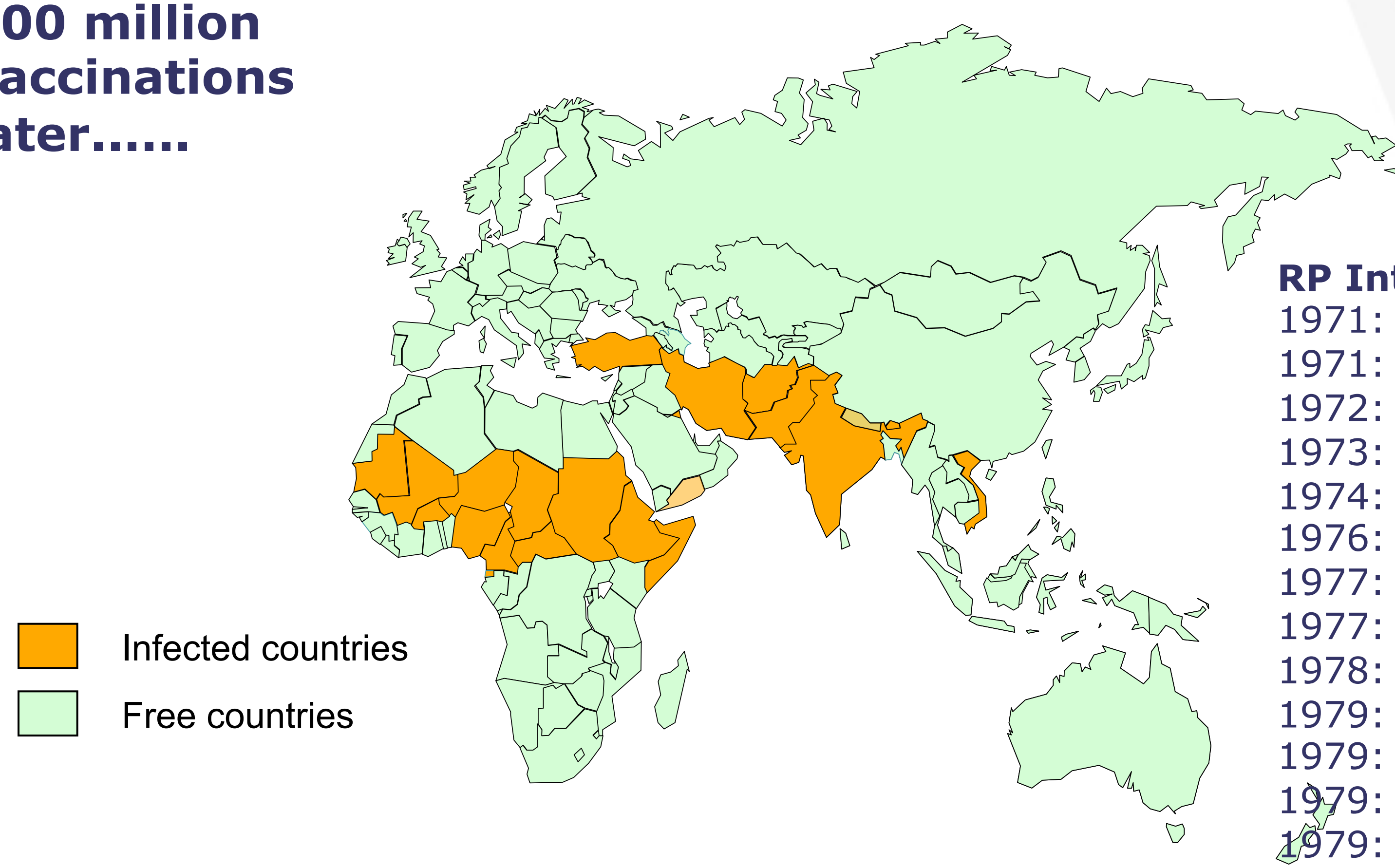
Infected countries

Free countries

RP Introductions
1962: Bahrain
1963: Nepal
1965: Saudi Arabia
1965: Yemen (PDR)
1966: Libya
1968: Bhutan
1969: Iran
1969: Bahrain
1969: Yemen (PDR)

Rinderpest Occurrence 1970

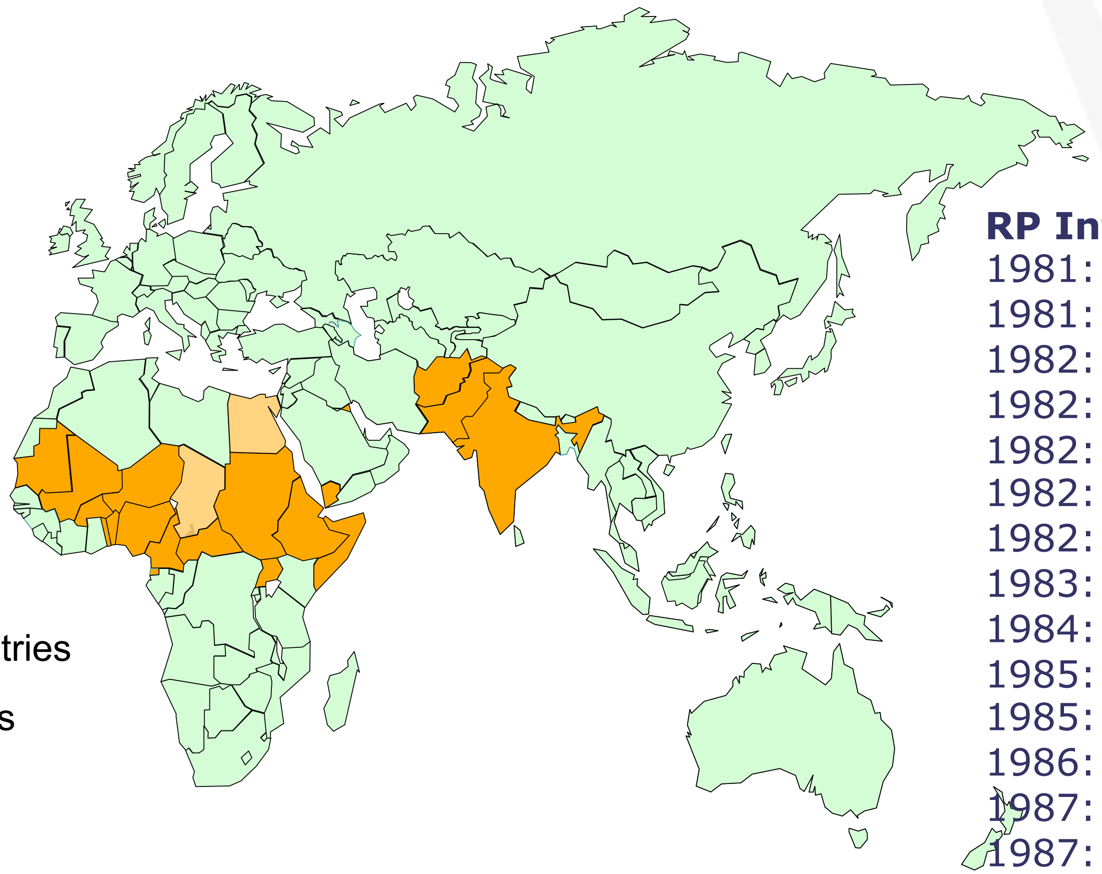
400 million vaccinations later……



RP Introductions
1971: Syria
1971: Jordan
1972: Angola
1973: Ghana
1974: Benin
1976: Yemen (AR)
1977: Lebanon
1977: UAE
1978: Senegal
1979: Saudi Arabia
1979: Oman
1979: Uganda
1979: UAE

Rinderpest Occurrence 1980

700 million vaccinations later……



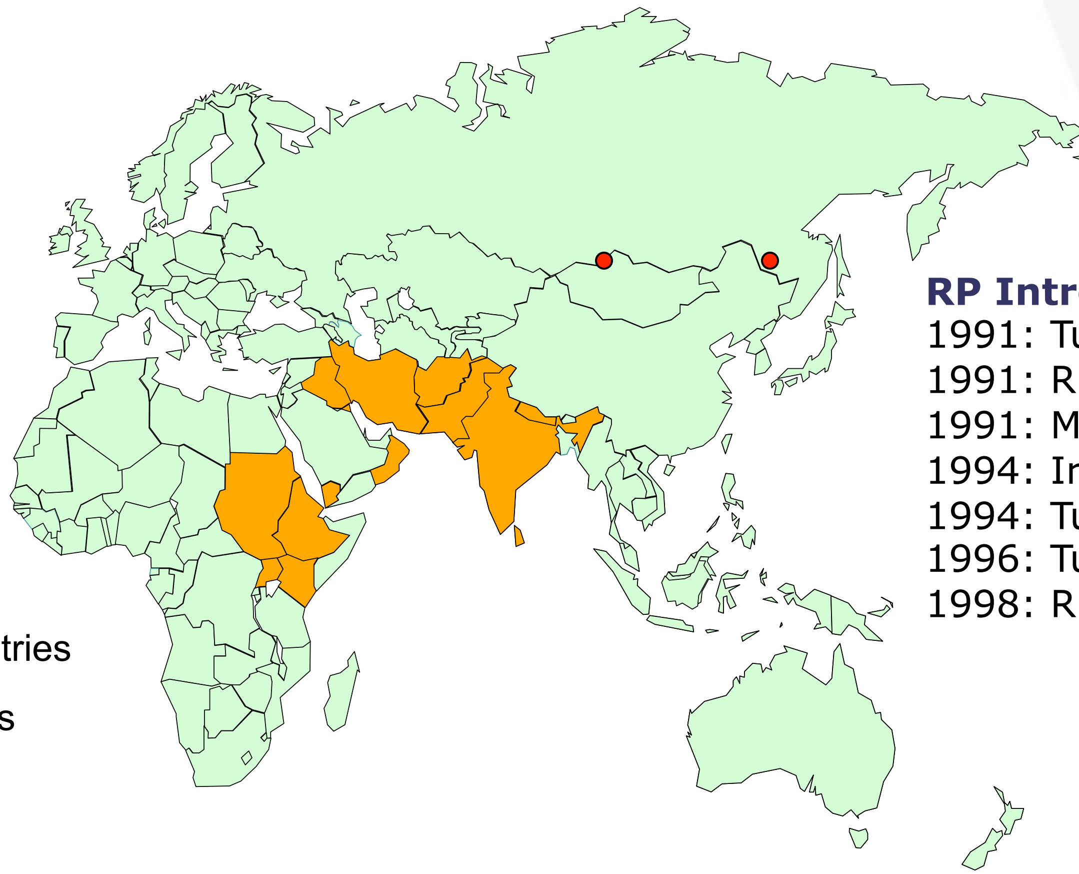
Infected countries

Free countries

RP Introductions
1981: Tanzania
1981: Iran
1982: Egypt
1982: Turkey
1982: Syria
1982: Israel
1982: Oman
1983: Saudi Arabia
1984: UAE
1985: Bahrain
1985: Iraq
1986: Nepal
1987: Sri Lanka
1987: Iran
1988: Bahrain
1989: Georgia

Rinderpest Occurrence 1990

1,000 million vaccinations later……



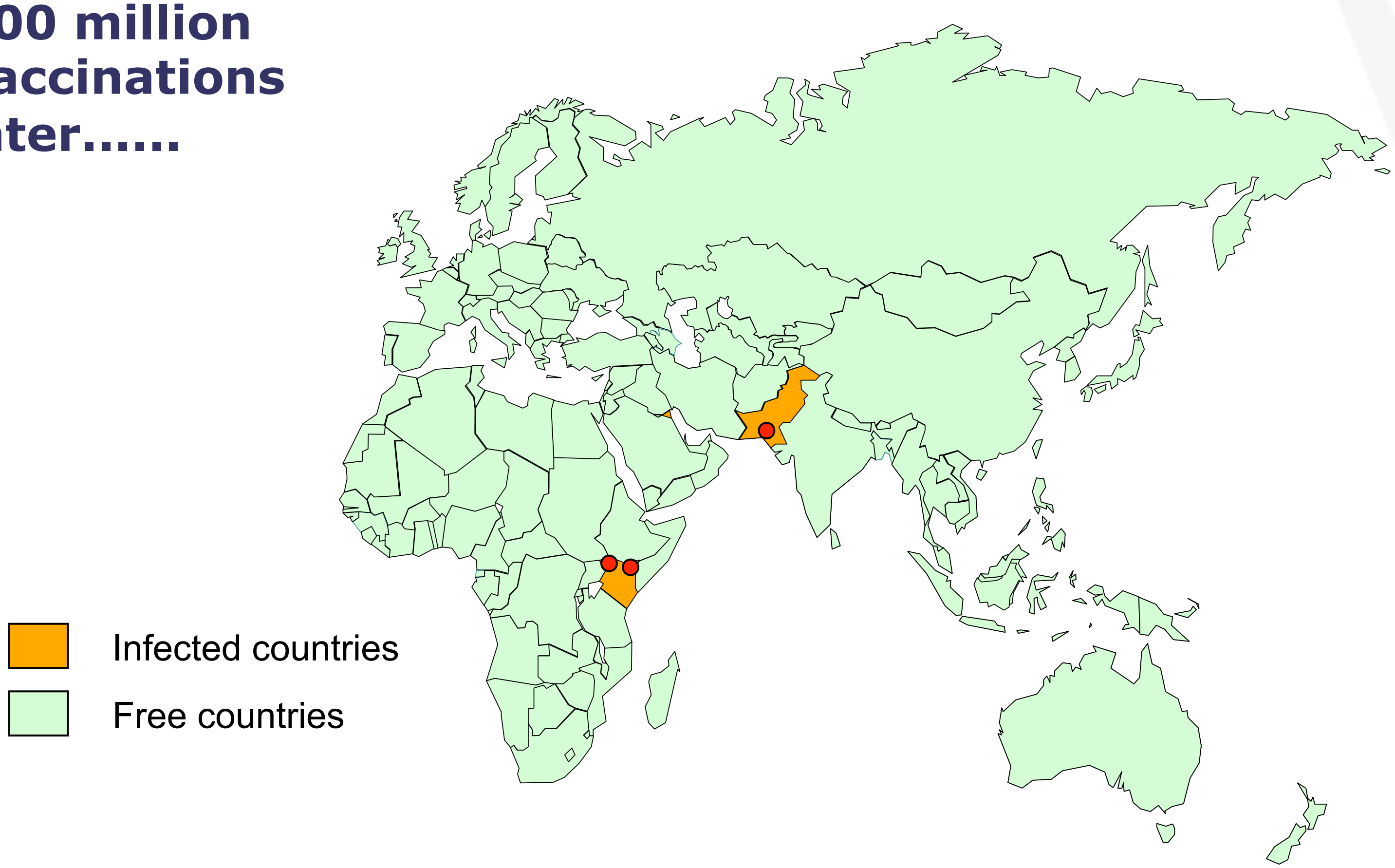
Infected countries

Free countries

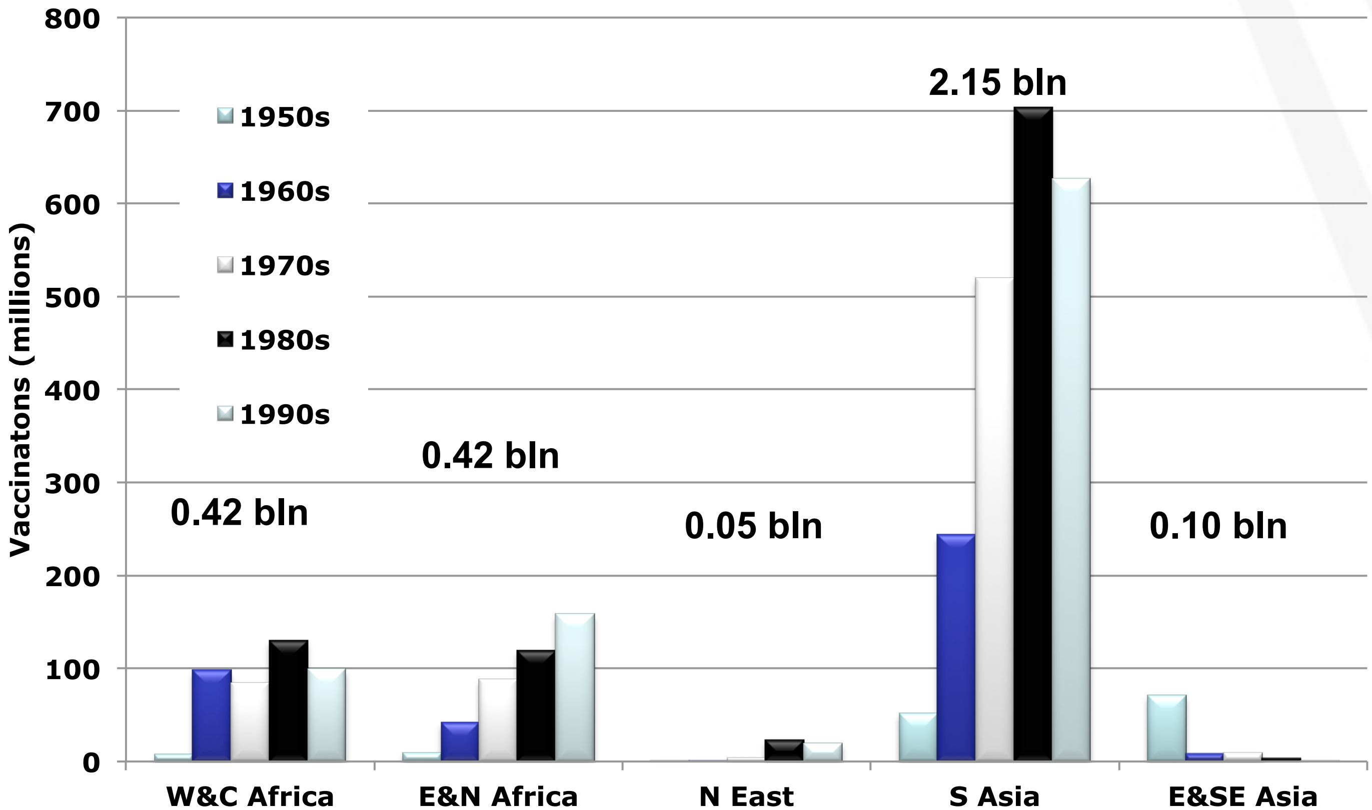
RP Introductions
1991: Turkey (east)
1991: Russia (Tuva)
1991: Mongolia
1994: Iran
1994: Turkey (east)
1996: Turkey (east)
1998: Russia (Amur)

Rinderpest Occurrence 2000

900 million vaccinations later……



Vaccinations by Region & Decade



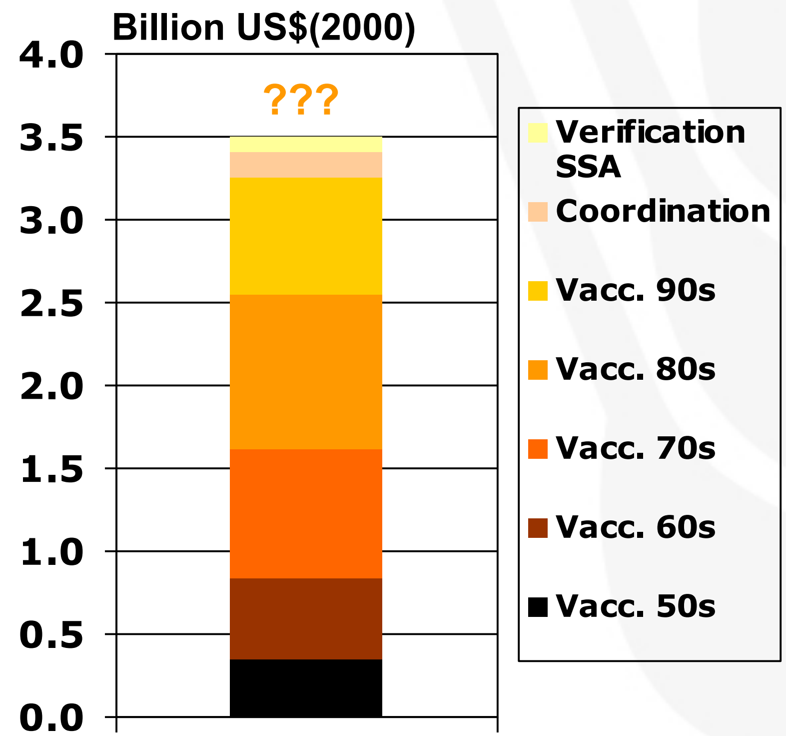
Total: 3.15 billion vaccinations

Vaccination Cost / Head

Country	Period	Animals vaccinated	Cost in 2000US$
Nigeria	63 – 65	21,099,000	0.44
Niger	62 – 67	12,201,000	1.20
Mali	64 – 69	10,932,000	0.83
Chad	62 – 69	10,366,000	1.31
Senegal	67 – 69	6,413,000	0.70
Cameroon	62 – 67	2,076,000	1.31
Ivory Coast	64 – 69	793,000	2.63
JP15 I-III	**62 – 69**	**79,768,000**	**1.26**
Ethiopia	90 – 96	50,015,000	0.48
Mali	89 – 96	14,479,000	0.70
Tanzania	93 – 97	10,749,000	0.51
Senegal	90 – 97	10,336,000	0.81
Uganda	92 – 97	8,981,000	0.87
Ivory Coast	90 – 97	3,689,000	3.02
PARC	**86 - 99**	**122,517,000**	**0.79**
Senegal	1996	547,735	0.24
Mauritania	96 – 98	???	0.42

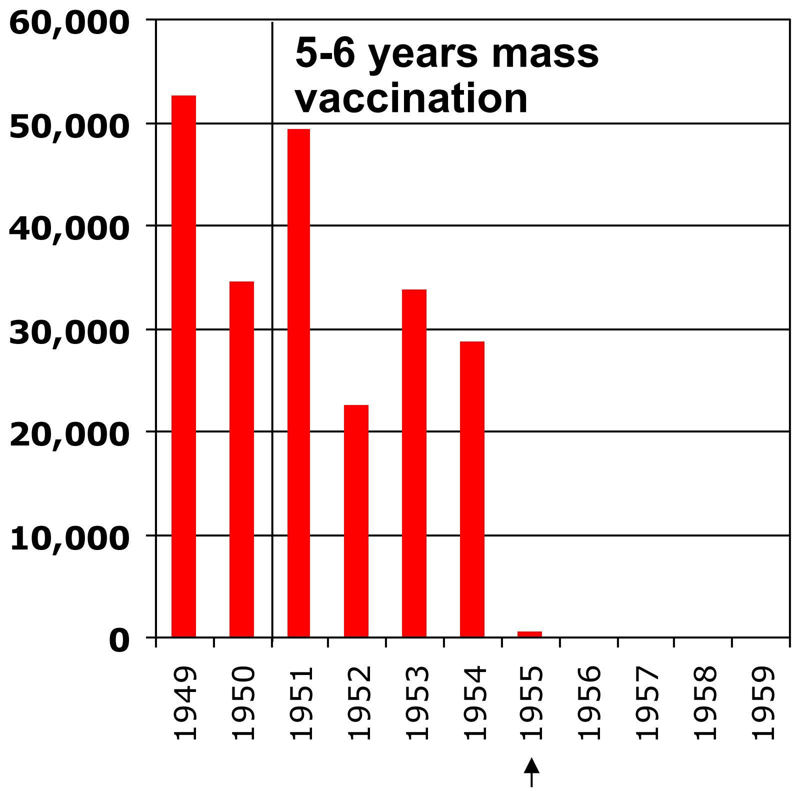
App. Total Cost of Eradication

- Vaccination 1950s: US$2.50
- Vaccination 1960s: US$1.25
- Vaccination 1970s: US$1.10
- Vaccination 1980s: US$0.95
- Vaccination 1990s: US$0.80
- Coordination: 5% (JP15 3%)
- Verification SSA: PACE & SERECU (EUR81 million)
- Verification ROW: **???**
- Miscellaneous (research, quarantines, movement control, etc): **???**



Total cost of eradication since 1950s very likely to be less than US$ 5 billion !!

China, RP Deaths (Bovines)

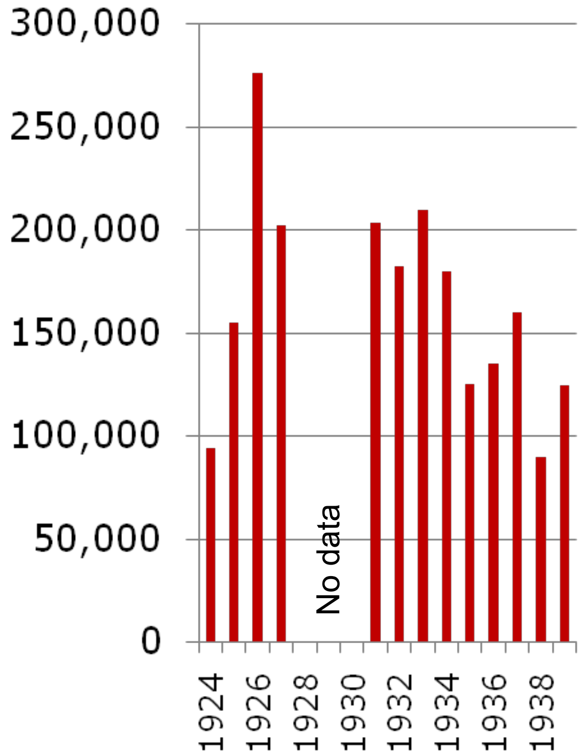


0.95 deaths/ 1,000/year

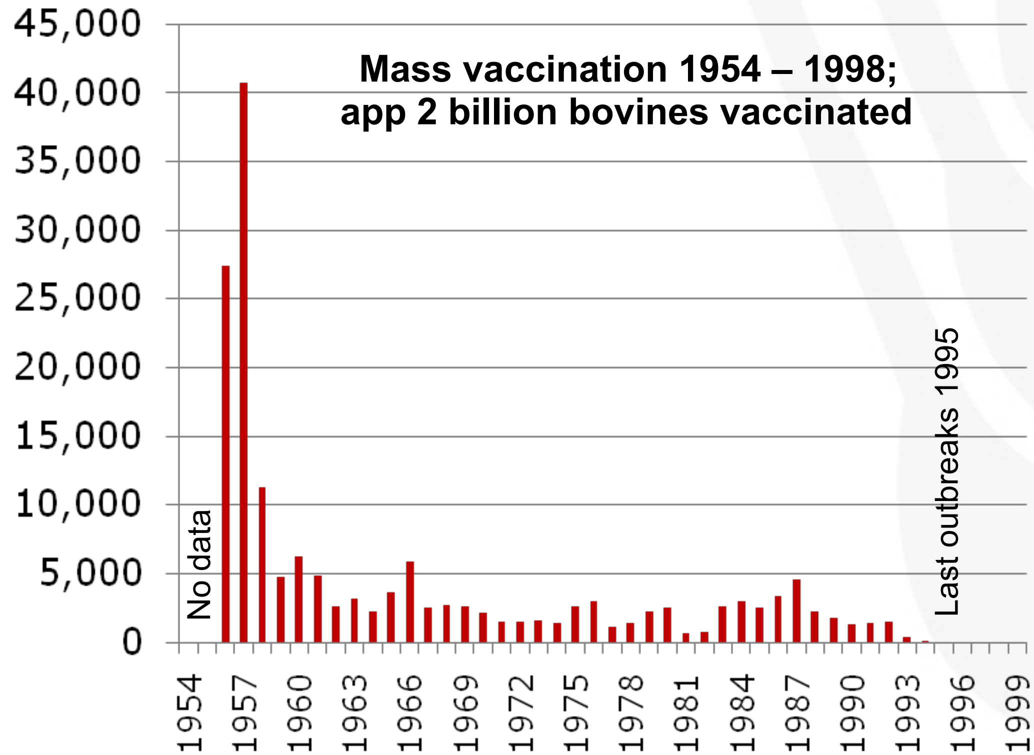
0.008 deaths/ 1,000/year

CFR: 89% !!!

India, RP Deaths (Bovines)



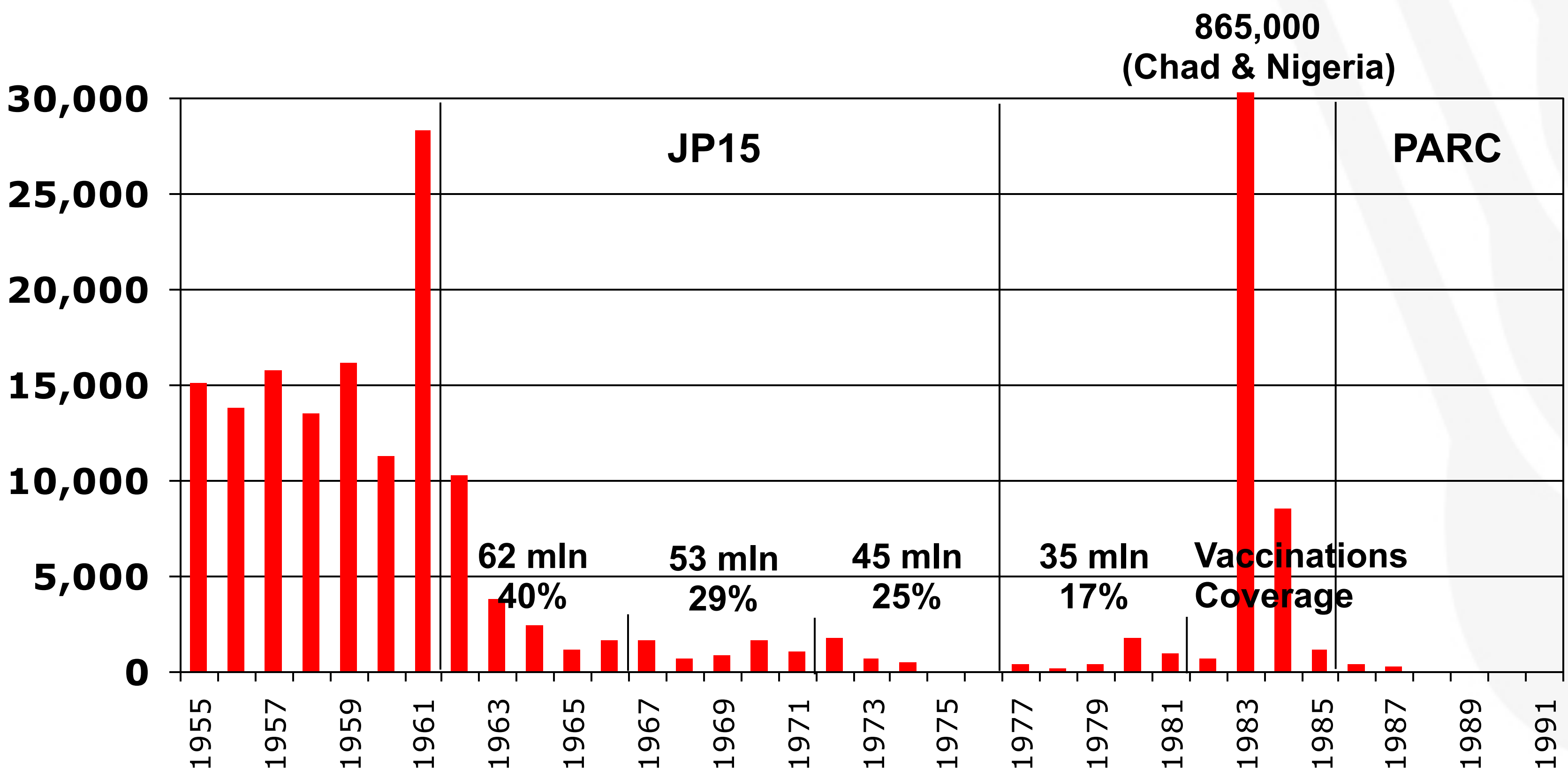
1.04 deaths/1,000/year



0.012 deaths/1,000/year

CFR: 45%

West Africa, RP Deaths (Cattle)



0.66 deaths/
1,000/year

0.02 deaths/1,000/year
CFR: 54%

Interim Conclusions

- Global eradication could have been 'cheaper' still had the 'Chinese model' been followed.
- But, conventional control (pre-mass vaccination) kept rinderpest at bay (1 RP death/1,000/year).
- Routine vaccination at 25-30% coverage further reduced annual RP-specific mortality to 1 to 2 animals 100,000.

Costs vs. Benefits, Current State of Knowledge

- **What we know** (surprisingly, not a lot …)**:**
  - Estimates of global impact are **BIG**:
    - Normile (2008) from FAO: US$610 million to date in control costs versus **annual benefits of US$1 billion per year for Africa** alone
    - Catley (2005), also from FAO: during 1965-1998 estimated benefits at **US$289 billion for India**, **US $47 billion for Africa**
    - **Global BCR** would thus be at least **67** (336:5)
  - But, these "global" estimates of benefits are not supported by any systematic economic analysis (best guesses?)

Costs vs. Benefits, Current State of knowledge

- At country or case study level, existing economic estimates based on more rigorous economic analyses
  - BCA, welfare analysis, social accounting matrices (and combinations)

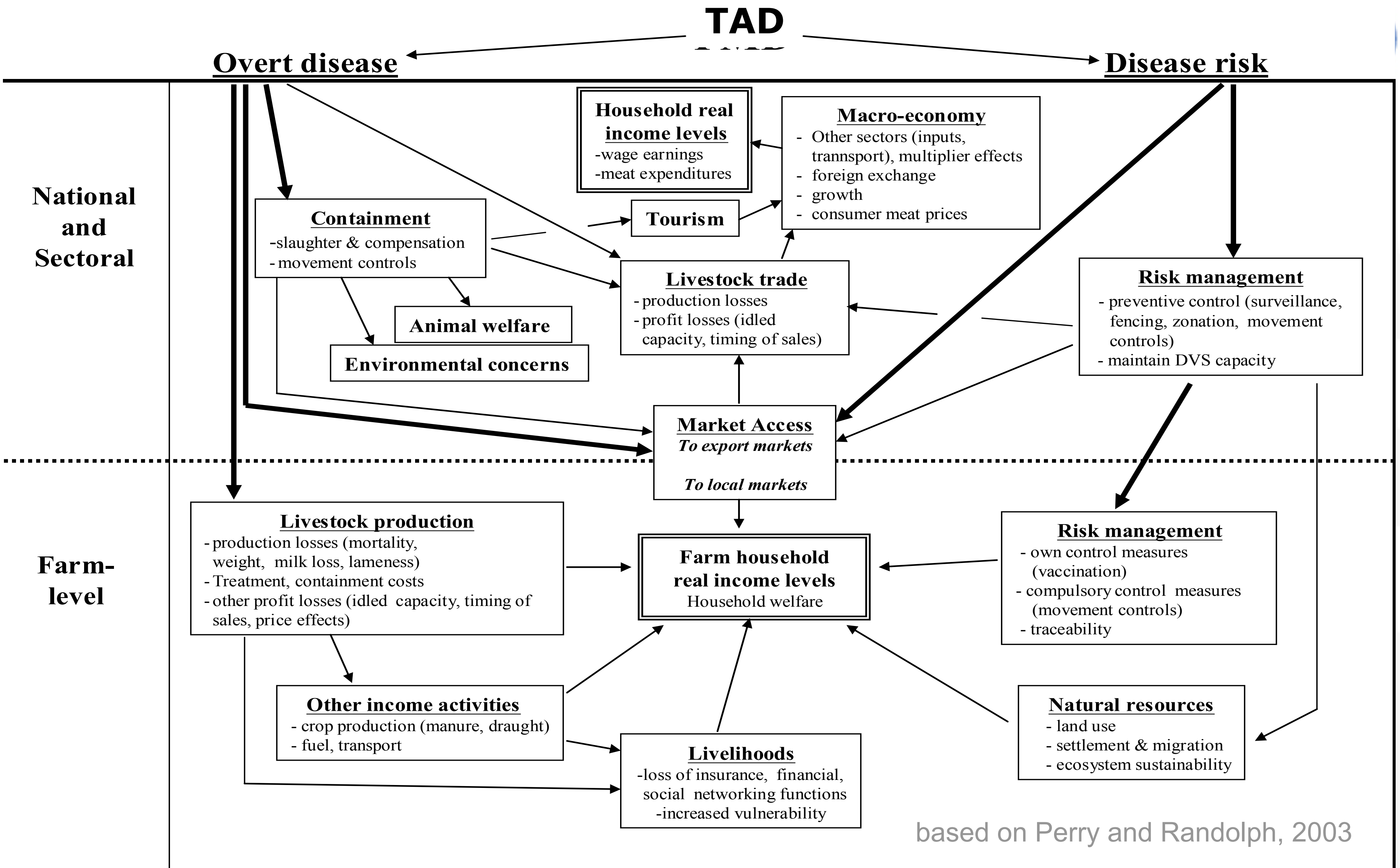
- Benefit-cost ratios from such studies are usually also high but very variable:
  - **1.06-3.84** for PACE (Tambi et al. 1999)
  - **2.48** for JP15 in Nigeria (Felton and Ellis 1978)
  - **34** for Southern Sudan (Blakeway 1995)
  - **138** for JP15 and **32** for PARC in Ethiopia; **171** for JP15 and **66** for PACE in Kenya (Omiti and Iringu 2010)

Costs vs. Benefits, Current State of Knowledge

- Approach:
  - Benefits: mainly changes related to mortality and avoided losses (animals and related sectors).
  - Costs associated with and without programs

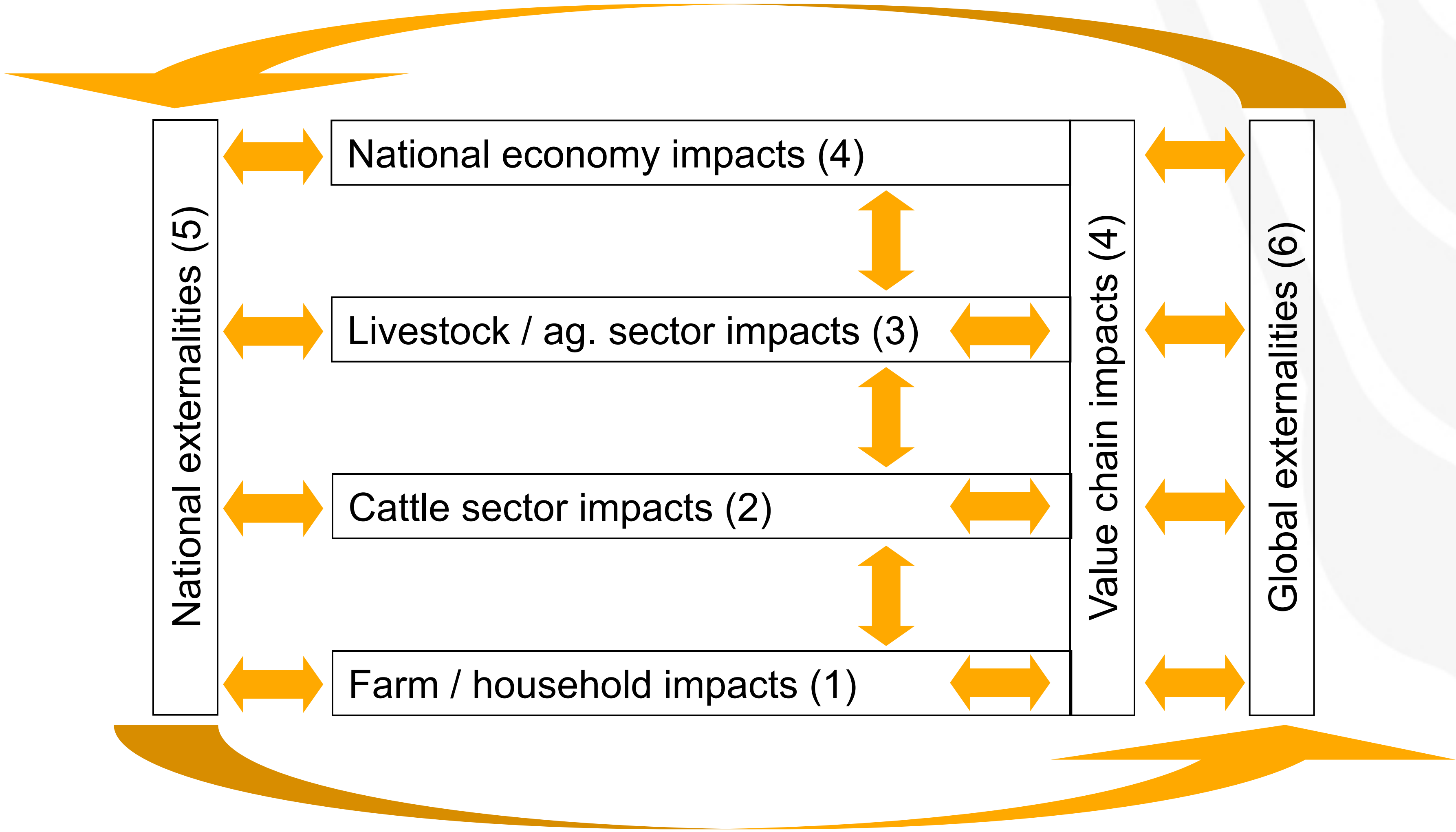
- But …
  - No/limited price effects (maybe an OK assumption?)
  - Limited quantification of downstream impacts (trade, macro impacts) – more problematic.
  - No changes in behaviour (producer behaviour, herd dynamics)
  - Unintended consequences (feedbacks with carrying capacity of resource base, e.g. stunting reduces meat protein yield of forage)?
  - No 'international' consequences considered

Impact Pathways of TADs



based on Perry and Randolph, 2003

Impact Pathways of TADs



TAD Impact Assessments

- Focus of most TAD impact studies (including rinderpest) has been on level 1 (sometimes levels 2 and 3).
- What's missing is **behaviour** – how does the system (individuals & institutions) adjust to an intervention?
  - Herd demographics: different dynamic patterns of herd growth
  - Marketing dynamics: adjustments in herds themselves in response to lower risk
  - These will influence with vs. without comparisons of disease *ex-post*
- **Off-farm / 'macro' impacts** also potentially significant, as are **externality impacts** within and across borders

Chad Case Study, Approach

- Sequential strategy of measuring impacts at different levels
- Step 1: define counterfactual scenario based on biological impacts (with vs. without) and associated costs
- Step 2: calculate sector-level benefits with vs. without at different stages of the livestock sector, incorporating behaviour aspects (levels 1-3)
  - "Simple" accounting framework
  - Utilization of population model (DynMod) to capture herd dynamics

Chad Case Study, Approach

- Step 3: Compute additional costs associated with rinderpest control to benefits as calculated in step 2
  - Derivation of sector-level benefit-cost ratio
- Step 4: Compute multipliers from available SAMs (level 4)
  - Growth linkages and value chain effects
  - Short-run impacts of control (without adjustments)
  - Decomposition of multipliers to assess livelihood effects
- Step 5: Long-term dynamic impacts via CGE analysis based on counterfactual scenarios (levels 4 & 6)

Chad Case Study, Method

- Counterfactual scenario: in absence of campaigns like JP15, etc., disease is controlled mainly by movement controls and targeted interventions when disease discovered.
  - i.e., similar to situation in 1950s
- So, added costs would simply be those incurred during control campaigns
- What about ‘added’ benefits?

Chad Case Study, Method

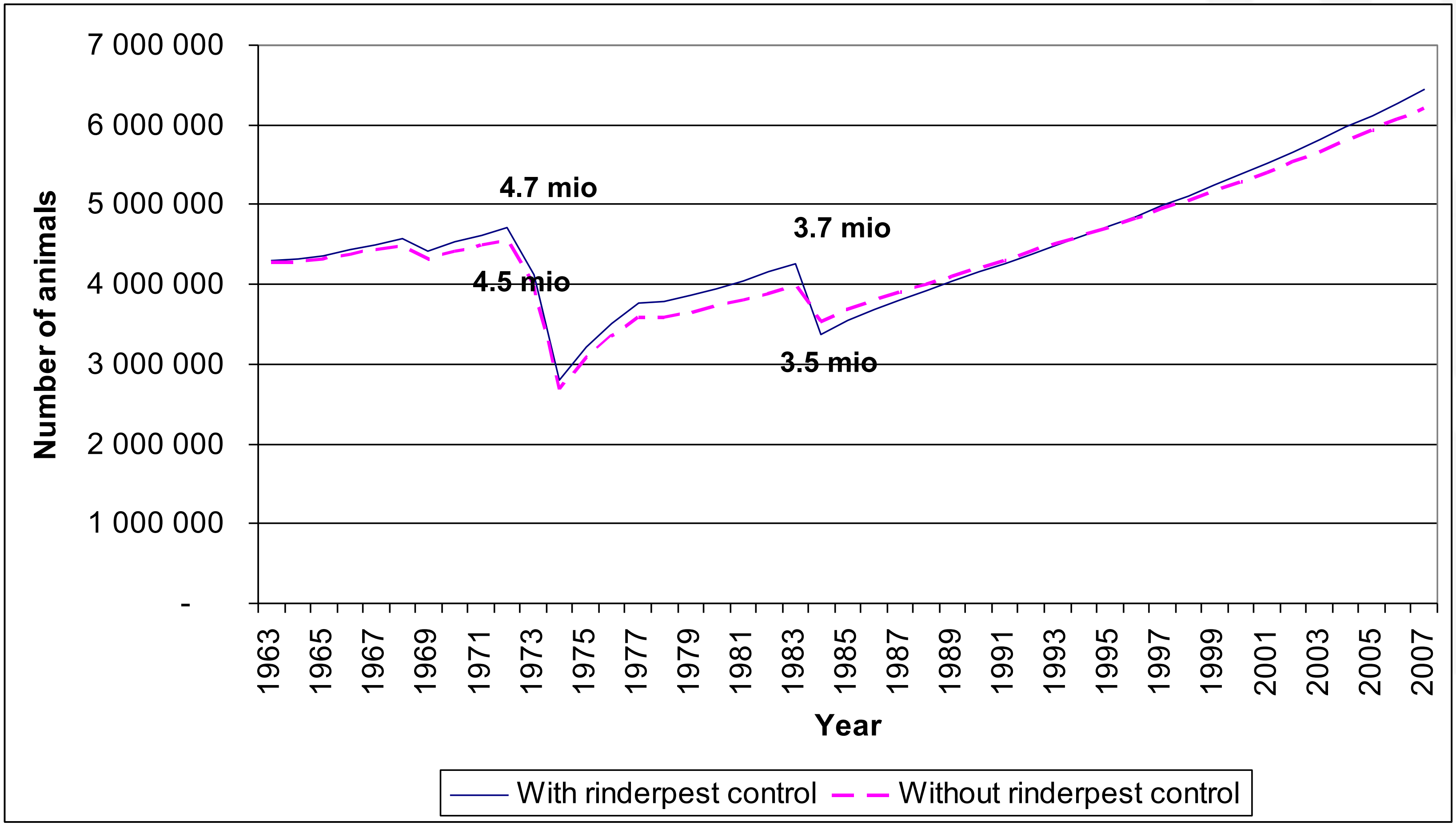
- At a sector-level, first need to tease out the additional benefits from lower mortality based on rinderpest campaigns.
- Use of DynMod (Lesnoff et al. 2007; 2008) to project cattle population figures with and without rinderpest control

Chad Case Study, Method

- "Without control" case applies average mortality rates per outbreak from observed data (1963-1970) to observed number of outbreaks in data available pre-JP15 (1958-1961)
  - Additional 0.33% mortality due to rinderpest (e.g. mortality of young females 11.53% instead of 11.2%)

- For 1984 drought, shocks decomposed into mortality and rinderpest shock
  - Assumed rinderpest accounted for 35% of deaths in 1984
  - These deaths assumed *not* to occur in "without" case (low-level endemicity of disease)

Chad Case Study, Results

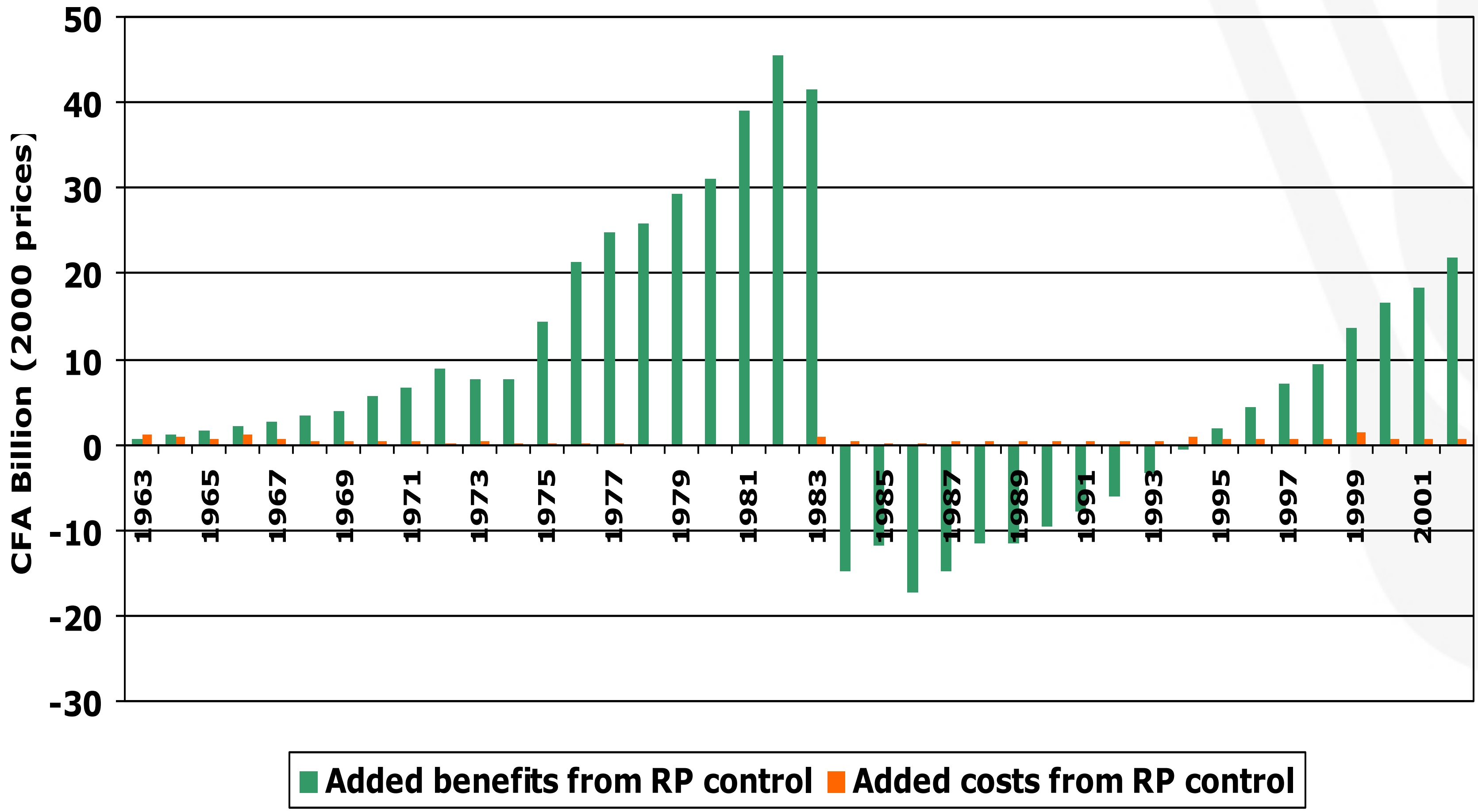


Chad Case Study, Method

- Population projections then decomposed at sector level to value benefits with vs. without:
  - Animals
  - Meat
  - Milk

- Assumptions and caveats:
  - No price effects assumed
  - All figures converted to real CFA (2000) using WDI GDP deflator
  - Simple accounting framework given limited data

Chad Case Study, Results



Chad Case Study, Results

- **Cattle sector-level** benefit-cost ratio over 1963-2002 estimated at **16.45**
  - Much higher than Tambi et al. (1999) estimates, reflecting longer time horizon
  - Lower than some Omiti & Irungu (2010) estimates.

- First-round effects only partly assessed as many benefits and costs poorly estimated due to lack of data.

Chad Case Study, Results

- Economy-wide impacts
  - Use of social accounting matrix (Garber 2000) for Chad to assess multipliers and perform 'short-run' analysis

  - Multiplier analysis suggests strong linkages between livestock and broader economy. Activity multipliers:
    - 3.5 on total economic output
    - 2.6 on household incomes

  - In the year 2000, without eradication:
    - Income of rural households would be 8.5% lower, that of other households 2.5-3.5% lower;
    - Agriculture output would be nearly 6%, manufacturing 3.4%, and informal sector nearly 5% lower;
    - GDP % lower compared to "with eradication case".

Chad Case Study, Deficits

- Leading to possible underestimation of costs
  - ????
- Leading to possible over-estimation of benefits
  - Above 'average' RP-specific mortality
  - RP incidence higher in drought years, animals might die anyway
  - Equal distribution of mortality over all age groups
  - Non-consideration of salvage options / values
  - Non-consideration of carrying capacity constraints

- Leading to possible over-estimation of costs
  - Vaccination costs more than 50% higher than those for Mali (but similar to those of Niger)
  - RP vaccination combined with vaccination against CBPP and leading to 'capacity establishment'
- Leading to possible under-estimation of benefits
  - Under-reporting of RP
  - Non-consideration of treatment costs
  - Non-consideration of production losses beyond mortality (reproduction, milk, draught, etc)
  - Non-consideration of risk mitigation costs (mgmt of herd structure and species composition, movement, etc.)
  - **Non-consideration of indirect benefits (multipliers)**

Was it worth it?

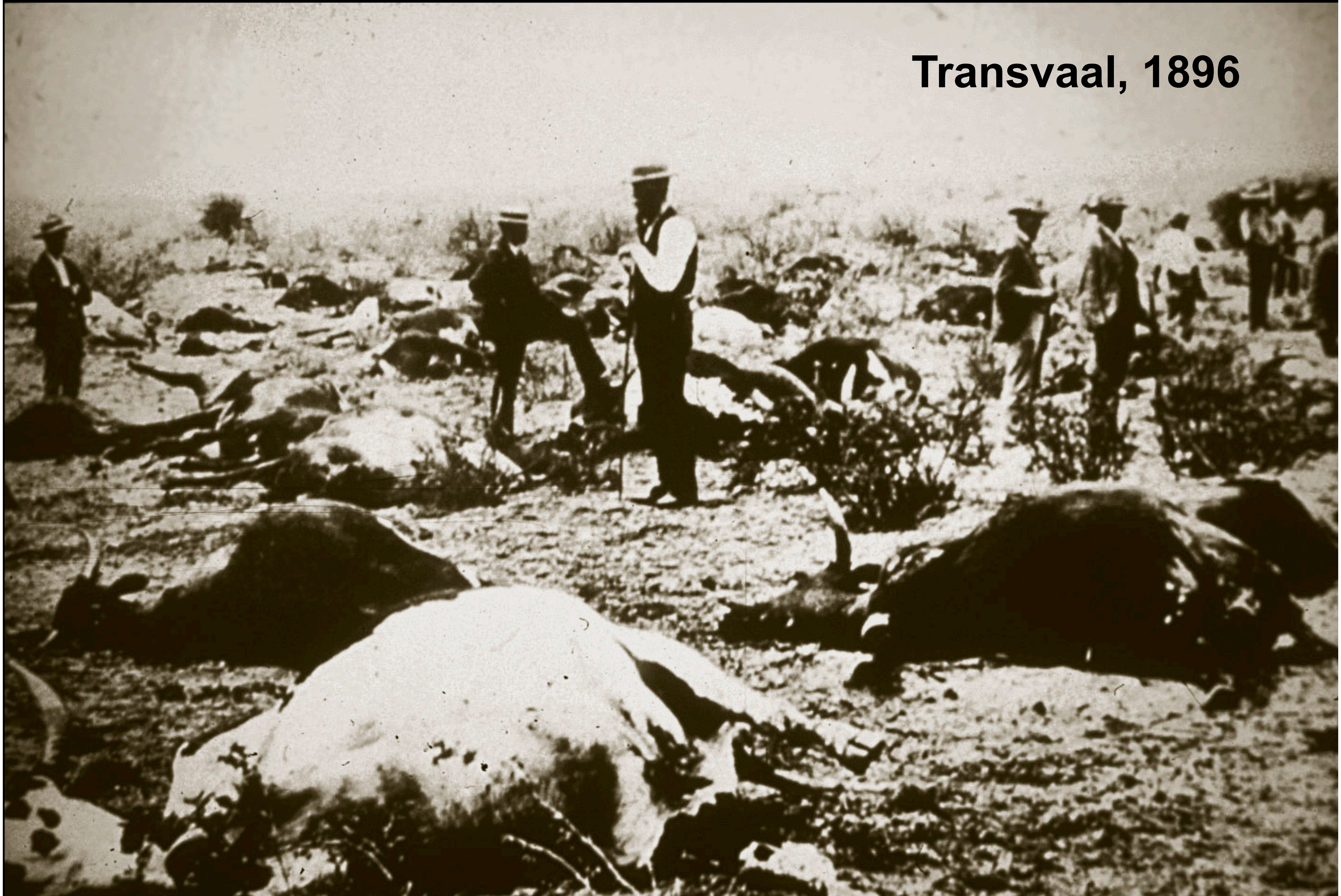
1. For Chad
   - CBA positive despite biases 'against' outweighing those 'in favour'.
2. For SSA
   - All 'partial' analyses report positive CBRs despite usually being limited to assessment of 'direct' benefits. CBRs are particularly favourable where draught power and milk are of specific importance (Kenya & Ethiopia).
3. For South and East Asia
   - Extrapolating from Kenya and Ethiopia very probably.
4. For NENA
   - Definitely – one incursion every 2 years over the past 40 years.
5. The World as a whole
   - (1 + 2 + 3 + 4) * X

Next Steps

- Improve the 'analytical model' to address main deficits (find compromise between the desirable and feasible)
- Support AU-IBAR to carry out 'CBAs' for a larger number of countries in SSA (check robustness of analyses)
- Expand analysis from country to regional level (SSA with AU-IBAR)
- Carry out analysis for India (as largest single 'contributor') and Pakistan
- Estimate rinderpest risk and cost (of risk mitigation and / or incursion) for 'free' countries

Afterthoughts

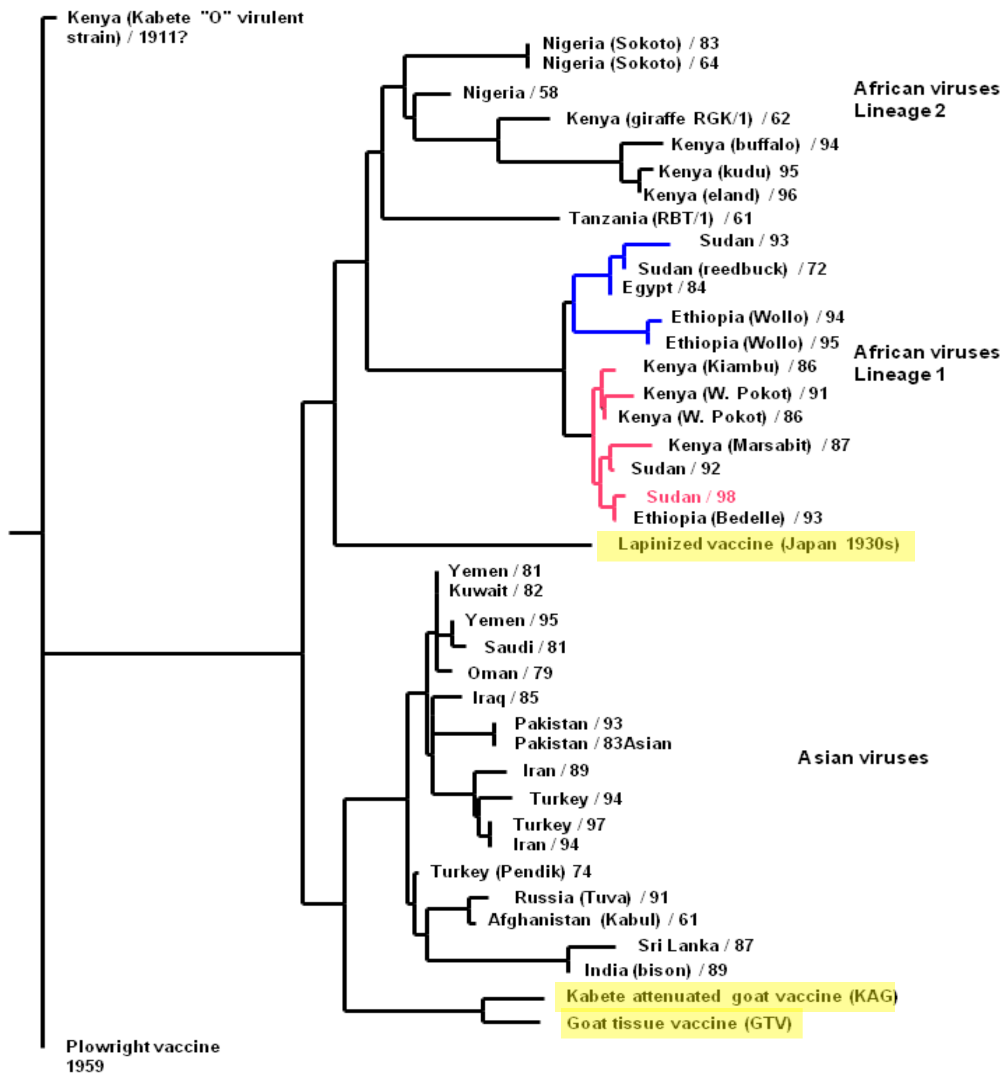
- Global eradication of a 'dumb' virus took 50 years, how long would it take to eradicate a 'smart' virus?
- Although on a global scale US$ 5 billion over 50 years is 'peanuts', raising US$100,000,000 per year for the control of an animal disease is beyond the scope of any single institution.
- Thus, despite being the 'No 1' animal disease globally, the lion's share of the cost of RP control / elimination was borne by individual countries at different times (international contributions were catalytic at best).
- Consequently, 'second best' options, i.e. control of disease where it hurts most may prove to be the best short / medium-term strategy


Transvaal, 1896

Application

- Improve the ‘model’ (find compromise between the desirable and feasible)
- Support AU-IBAR to carry out ‘CBAs’ for a larger number of countries in SSA (check robustness of analyses)
- Expand analysis from country to regional level (SSA with AU-IBAR)
- Carry out analysis for India (as largest single ‘contributor’)

Phylogenetic Tree of Rinderpest Viruses



Added Analytical Challenge

How to reconcile disease-related contextual characteristics with impacts at different levels of analysis?

1. Disease specifics 2. Production characteristics 3. Market characteristics 4. Livelihoods characteristics 5. Control characteristics	Vs.	1. Farm / household level 2. Cattle sector level 3. Livestock / ag. sector level 4. Value chain & natl. econ. level 5. Indirect impacts (natl. level) 6. Indirect impacts (international / global level)

Chad Case Study

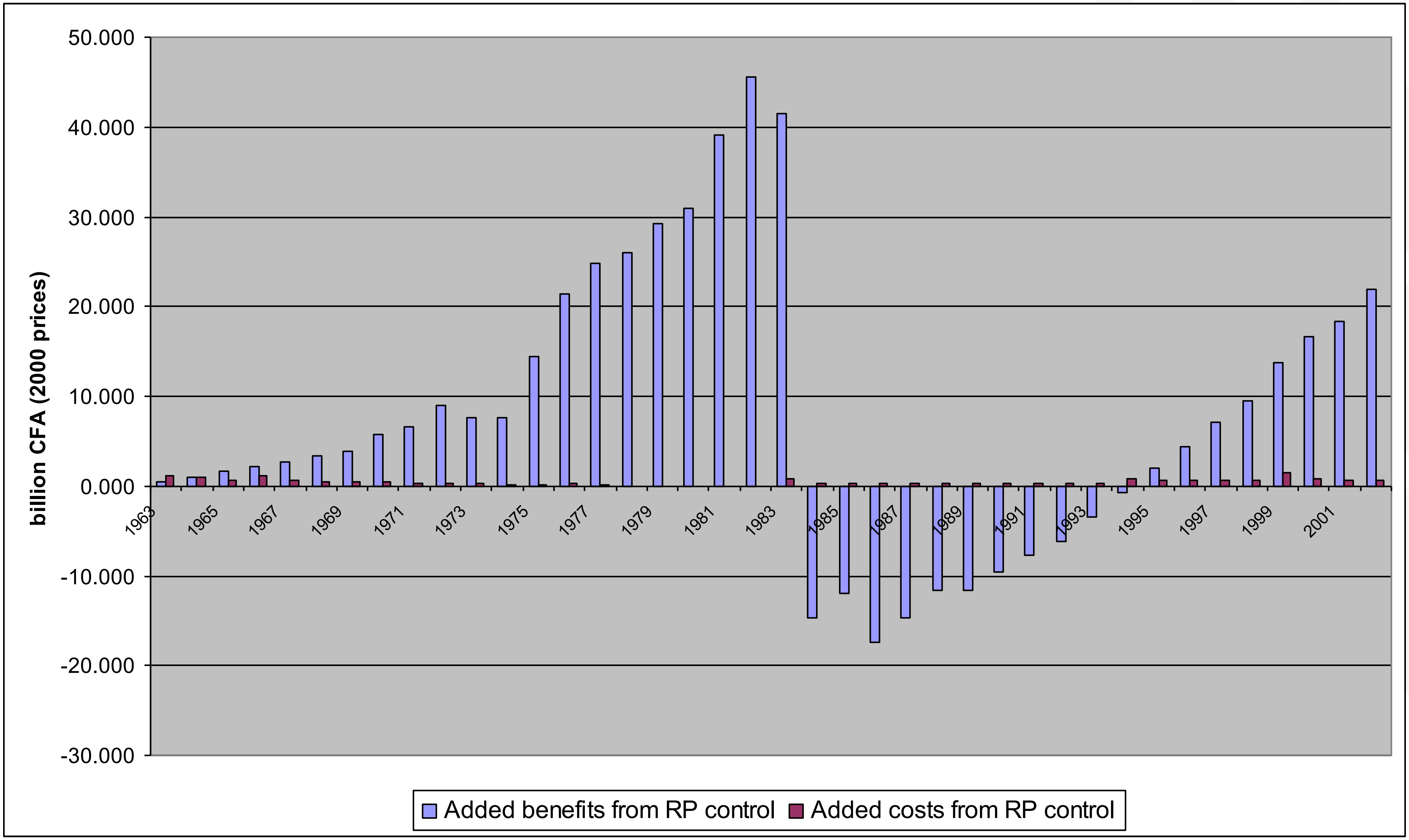
- DynMod allows for the projection of cattle population growth based on assumptions and observed data regarding:
  - Herd demographics
  - Offtake rates
  - Death rates
  - Reproduction rates

- These were calibrated based on assumptions from Lesnoff et al. (2008) applied in Niger and trends in droughts, etc. from FAO time series data.

Chad Case Study, Background

- Rinderpest in Chad:
  - First detected in 1913
  - 1913-1914 pandemic killed 1 million cattle, 70-80% of cattle stocks
  - Concerted efforts for control started in 1950s, but erratic in application until JP15 (1962)
  - JP15 successful in reducing outbreaks, but vaccination coverage post-JP15 inconsistent (29-44% during 1971-1977)
  - Major outbreak in 1983: about 5% of cattle herd killed (337,500 head)
  - PARC increased vaccination coverage, followed by sero-surveillance to confirm absence of disease.

Chad Case Study, Results



Chad Case Study, Results

- Short-run simulation analysis (using 2000 as illustrative year, based on costs/benefits from sector analysis) highlights the magnitude of economy-wide impacts.

- In the year 2000, without eradication:
  - Income of rural households 8.5% lower, that of other households 2.5-3.5% lower;
  - Agriculture output nearly 6%, manufacturing 3.4%, and informal sector nearly 5% lower;
  - GDP (at factor cost) 3% lower compared to “with eradication case”.

Issues to Address

- Large amount of externalities / spillover effects and adaptive behaviour.
- Problems of valuation / pricing of livestock services and commodities and disease control inputs and shifts in these prices resulting from disease control / eradication.
- Difficulties to 'capture' the dynamics of the transformation of the livestock sector and associated value chains over such a long evaluation horizon.

Externalities / Spillover Effects (Examples)

- Investments in capacity to control / eradicate rinderpest (epidemio-surveillance, laboratory diagnostics, vaccine quality assurance, CAHWs, etc.) also accrue to control of other diseases.
- Particular impact of rinderpest in mixed farming systems relying on draft power and linkages of livestock sector and agriculture with the rest of the economy.
- Effects of rinderpest (eradication) on wildlife and the environment.

Externalities / Spillover Effects (Examples)

RP incursion risk, e.g.

- Philippines 1955: 250 cases, 15,300 vaccinations.
- Bhutan: 1968, persisted for 4 years
- Near East epidemic: 1971 to 1973.
- Sri Lanka: 1987 to 1994, 18,000 deaths, 1.5 million vaccinations.
- Turkey: 1991, 6,000 deaths, 11 million animals vaccinated

Adaptive Behaviour (Examples)

- Farmers may hedge against rinderpest by managing herd composition (more small ruminants, more reproductive females) and herd movements.
- Rinderpest outbreaks in vicinity may lead to destocking and subsequent (drastic) price falls.
- Presence of rinderpest in neighbouring country prompts ‘defensive’ investment (e.g. border vaccination) in rinderpest-free countries.
- Rinderpest-free countries close markets to infected countries, thus eradication affects international trade flows.

Adaptive Behaviour (Examples)

Vaccinations after RP freedom

- Bangladesh: 400 million from 1959 to 1999.
- Myanmar: 18 million from 1957 to 1994.
- Thailand: 5 million from 1960 to 1995.
- Etc…..

Valuation / Pricing (Examples)

- Intangible goods, e.g. farmers' perceived value of reduced risk of herd loss.
- Non-marketed livestock services and products, e.g. savings and insurance function of livestock.
- Marketed products and services whose prices my be distorted by policy interventions (e.g. taxes, over-/undervalued exchange rate, subsidies, etc.)
- Domestic price shifts due to opening / closing of export markets.

Scope of CBA Version 1.1

- Aspects to include in the analysis without necessarily attempting most precise quantification:
  - Direct production and livelihoods impacts
  - Effects on herd structure, species composition (substitution between cattle and small ruminants)
  - Effects on crop output and overall economy (through value chains)
  - Trade impacts
  - Rinderpest-specific research (e.g. vaccine development) and surveillance costs
  - Coordination and verification costs

'Model' Development

- **Fine-tuning of sector-level CBA**: parameterization of changes in herd dynamics and linkages to productivity changes (beyond mortality) with and without rinderpest

- **Synergies micro and macro**: explicit linkages of micro parameterization to macro models
  - Direct incorporation into CGE scenarios

- **Models to capture externalities**
  - Platforms available?
  - How integrate with micro and macro models?
  - How to capture regional impacts?

RP Incursion Risk