INTERNATIONAL FOOD
POLICY RESEARCH INSTITUTE
sustainable solutions for ending hunger and poverty

IFPRI®

Flood and irrigation management in Nigeria Experiences, challenges and opportunities

Hiroyuki Takeshima (IFPRI)
Ephraim Nkonya (IFPRI)

July 9, 2014
Abuja, Nigeria

Outline

- Key international experiences in irrigation development
  - lessons for Nigeria
- Key international experiences on flooding outcomes
- Current irrigation status in Nigeria
  - Inherent challenges in the North Central and the South compared to the North

Irrigation development – International / historical perspectives

- Significant public investment into irrigation infrastructure (per arable land)
- Significant national R&D in varietal development (rice)
- Wet season irrigation expanded before dry season irrigation
  - adoption of supplementary irrigation often preceded
- Irrigation expansion in the tropics
  - Patterns different from temperate zone (high latitude) => implication to North Central to Southern Nigeria

Irrigation Infrastructure investment in Nigeria – less than some Asian countries

	Annual public investment into irrigation (2010 USD million / year, PPP)						Per arable land (2010 USD / ha, PPP)				
	50s	60s	70s	80s	90s	00s	60s	70s	80s	90s	00s
Sri Lanka	229	186	332	818			249	381	924		
Philippines		36	275	711			7	58	134		
India	2060	3338	5591	8493	11879		21	35	52	73	
Indonesia			1014	1972				56	104		
Nigeria			647	647	369	480		23	23	12	15

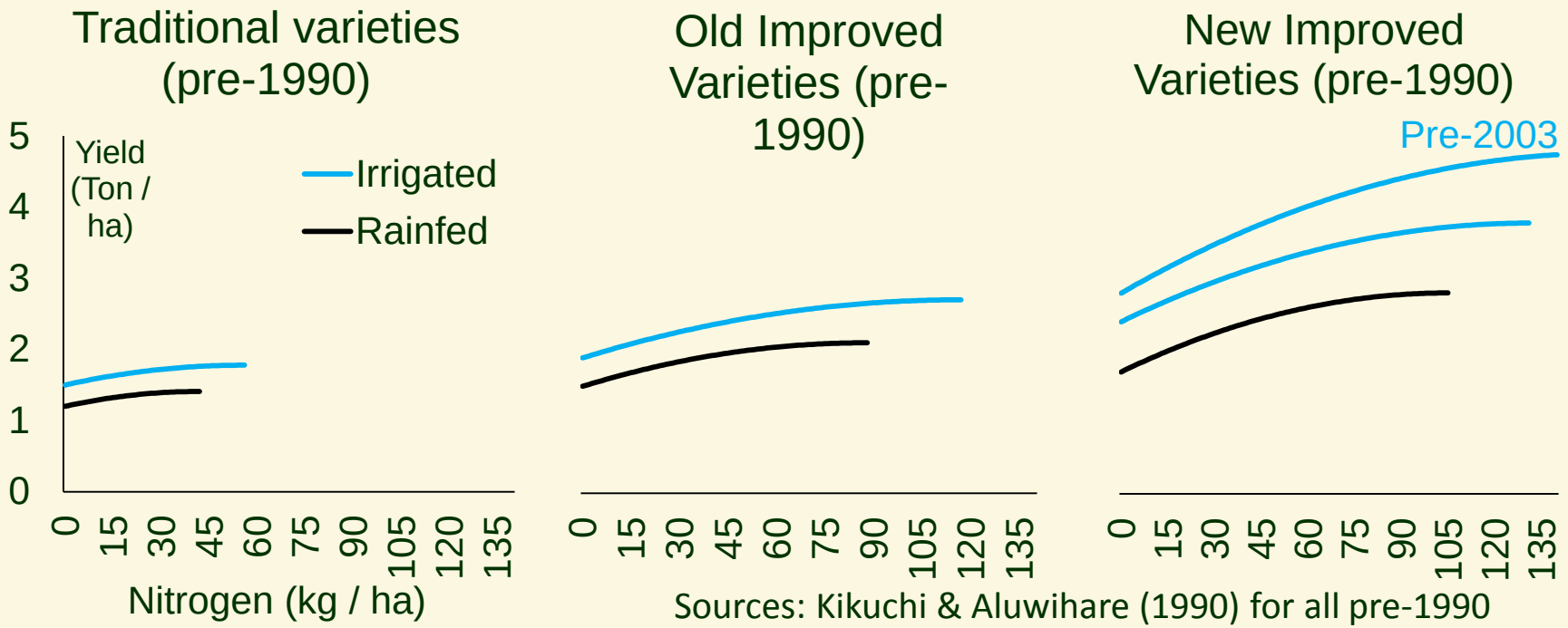
Table 1. Annual investment into irrigation[ab]

Source: Authors' modification based on various sources; Aluwihare & Kikuchi (1991) for Sri Lanka; For Nigeria, Foster & Pushak (2011) in 2001 – 06, Pagiola et al. (2002) for 90s, Pradhan (1993, p.21) for 70s and 80s; Kikuchi et al. (1978) for the Philippines; Thakkar (1999, Table 2B) for India; Rosegrant & Pasandaran (1993 Table 1) for Indonesia;

[a]Annual investment into irrigation includes new construction, rehabilitation, operation & management (O&M) and other small uncategorized expenditure. Not all studies, however, provide such disaggregation and categorization may vary across countries. Blank cells indicate missing data, not the lack of investment.

[b]For Nigeria, Pradhan (1993, p.21) only mentioned that Nigeria spent $3 billion in the two decades leading to early 90s. Assuming $150 million was spent each year for two decades, converting each year's figure into 2010 USD, as well as making PPP adjustment, we arrived at the presented figure of $647 million / year (2000 USD, PPP) for 70s and 80s.

Rice R&D in Sri Lanka - Increased response to irrigation (and nitrogen)



Sources: Kikuchi & Aluwihare (1990) for all pre-1990 figures, Kikuchi et al. (2003) for pre-2003 figure.

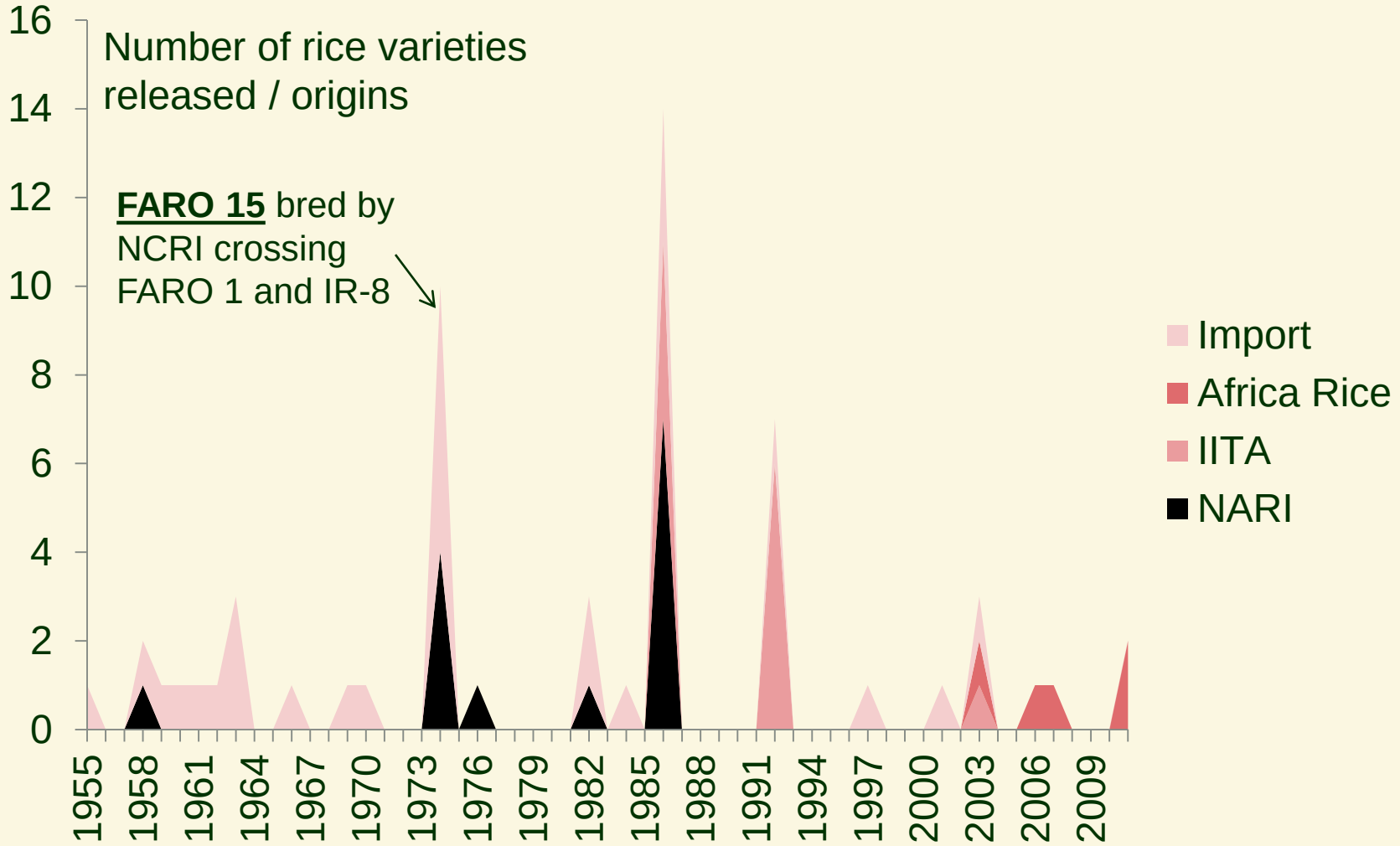
Low latitude
⇒ varieties from temperate zones were less transferrable
⇒ Invested heavily into domestic R&D

Increased returns to irrigation through domestic breeding efforts at several breeding stations across the country

Rice R&D

- Thailand invested since 1974 into deep-water rice (Jaroensathapornkul 2007)
  - breeding of deep-water rice emphasized
  - Short-stem varieties not appropriate enough for the lowland flooding area in Central Plain
    - RD1, RD2, RD3, RD7, RD11,RD17, RD19, RD23 and RD 25

Nigeria - No NARI-bred rice varieties released since 1987



Wet season irrigation expanded before dry season irrigation (rice)

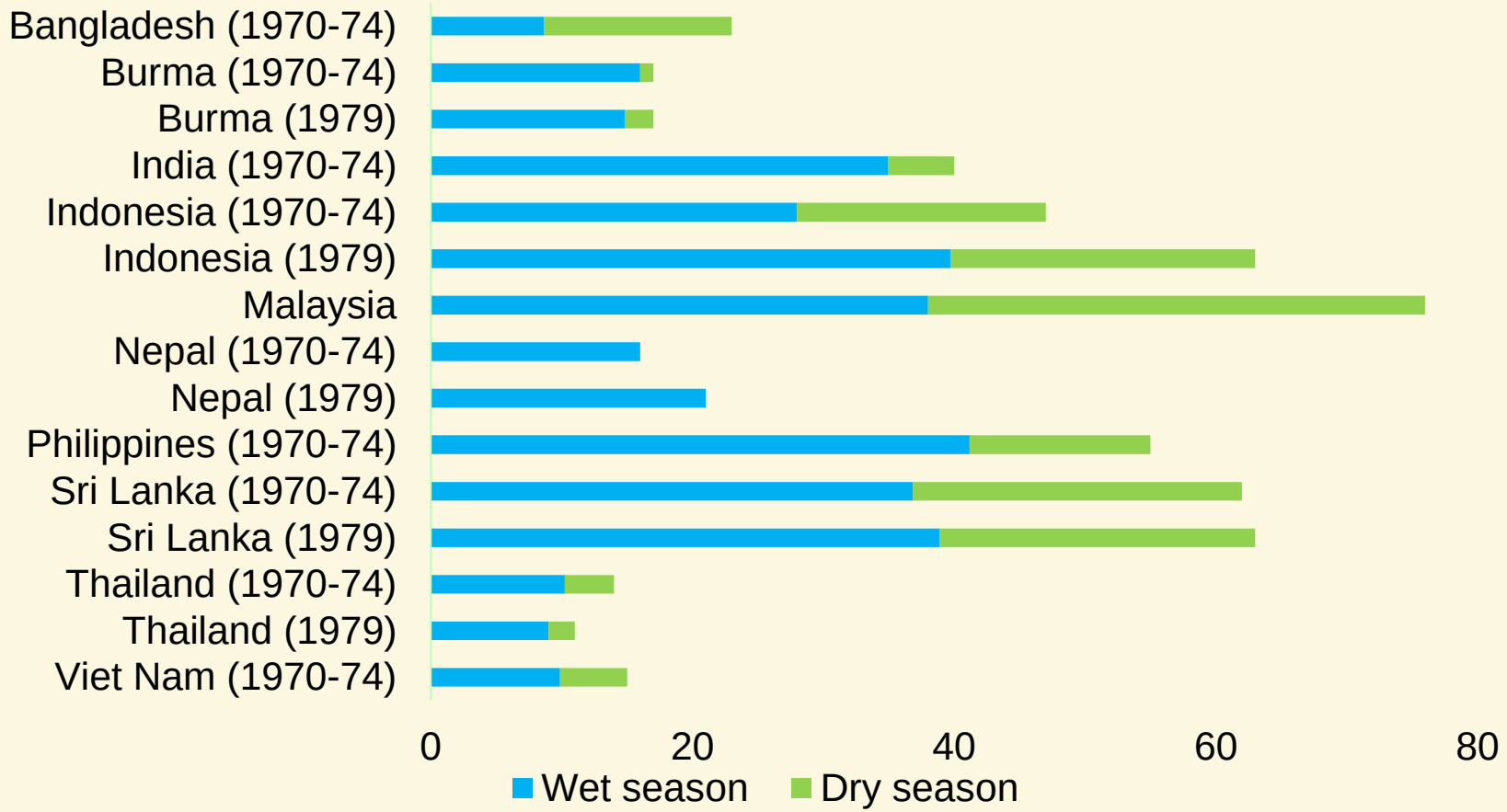


Table 5. Share of irrigated area among all rice area in selected counties

Source: For Asian countries, Authors' modifications from Chandler (1979, Table 3) and IRRI (1986c Table 2). Ahmed & Sampath (1992) for Bangladesh.

Irrigation expansion in the tropics

- **Rice**
  - Mostly small-holders adopting irrigation
- **Banana / plantains, sugarcane, some tropical vegetables (pepper)**
  - Irrigation limited to export-oriented large scale plantations
  - Investment into irrigation, R&D done by multinationals operating plantation
  - Public R&D also important for sugarcane
  - Smallholder – mostly rain-fed
- **Less irrigation for**
  - Temperate vegetables (tomato, onion etc)
  - Potatoes
  - Cotton
  - Some tropical vegetables (okra)

⇒ **This pattern is observed even in countries like Indonesia or Sri Lanka with much higher adoption of irrigation**

⇒ **Rice is probably one of the crops with higher irrigation potential for small-holder farmers in humid tropics in Nigeria**

Institutional innovations for irrigation

- Effective community-management - circumvented the tragedy of commons (Hayami & Kikuchi 2000 p134; Feeny et al. 1990; Ostrom 1990, 1992; Baland & Platteau 1996)
- Mutual dependencies, long-term relationships within community => farmers can craft rules over uses of common resources (Ostrom & Gardner 1993).
- Successful cooperation - when water supply is modest, rather than deficient (Bardhan 1993)

$\Rightarrow$ Communal management can work, but Incentives to develop institutions may be greater if sufficient public investments are provided into enhancing aggregate water supply

Large scale flooding – international experiences

- **Destruction of assets**
- **Out-migration**
  - Great Mississippi Flood of 1927, Bangladesh in 1988
  - Labor shortage - investment into capital
  - Implication on appropriate technologies
- **Flood mitigation measures (ex-post)**
  - Production-based entitlement (subsidized input distribution)
    - Though sometime negative effects on informal seed sector
  - Labor-based entitlement (public works, safety nets)
  - Trade-based (grain reserve management / food pricing policies)
  - Transfer-based (food aid, cash transfers)
    - Food distribution / trade liberalization effective - Bangladesh (1998)
- **Mixed effects on soil**
  - Soil erosion, silting of rivers, reduced water quality, reduced reservoir capacity
  - Sometimes bring in more fertility, nutrients

Successes in the past

- Agricultural transformation in the northern Nigeria during 90s (Goldman & Smith 1995)
  - Triggered by drought-tolerant OP maize
  - Induced investment into irrigation pump
- Irrigation pump in Fadama II
  - Insurance against rainfall risk (Takeshima & Yamauchi 2012)
  - Especially in the Northern Nigeria (Nkonya et al. 2010)
- Farmers' ability to adjust to changing water regime
  - Long term adaptions to the changing water regime after Tiga Dam construction (Thomas & Adams 1999)
  - Productive rice irrigation in Bakolori irrigation scheme (IFPRI's field work 2014)

Current challenges

DRY SEASON IRRIGATION NORTH CENTRAL AND SOUTHERN NIGERIA

Difference between the South and the North
Solar radiation / sunshine

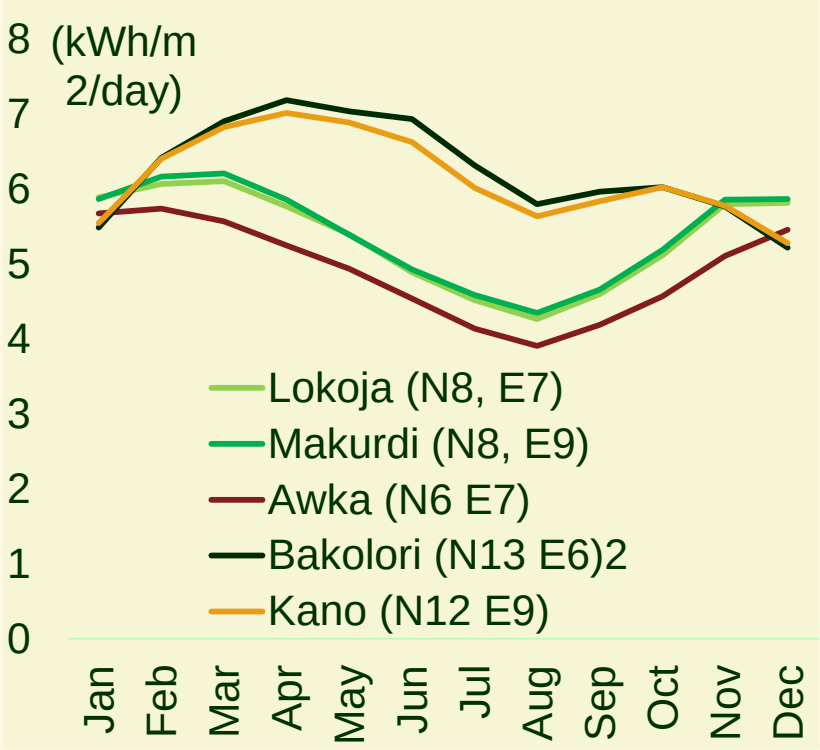


Figure 2. Solar radiation (kWh/m²/day, monthly average) in Lokoja, Makurdi, Awka and Northern Nigeria (Bakolori, Kano)
Source: NASA (2008)

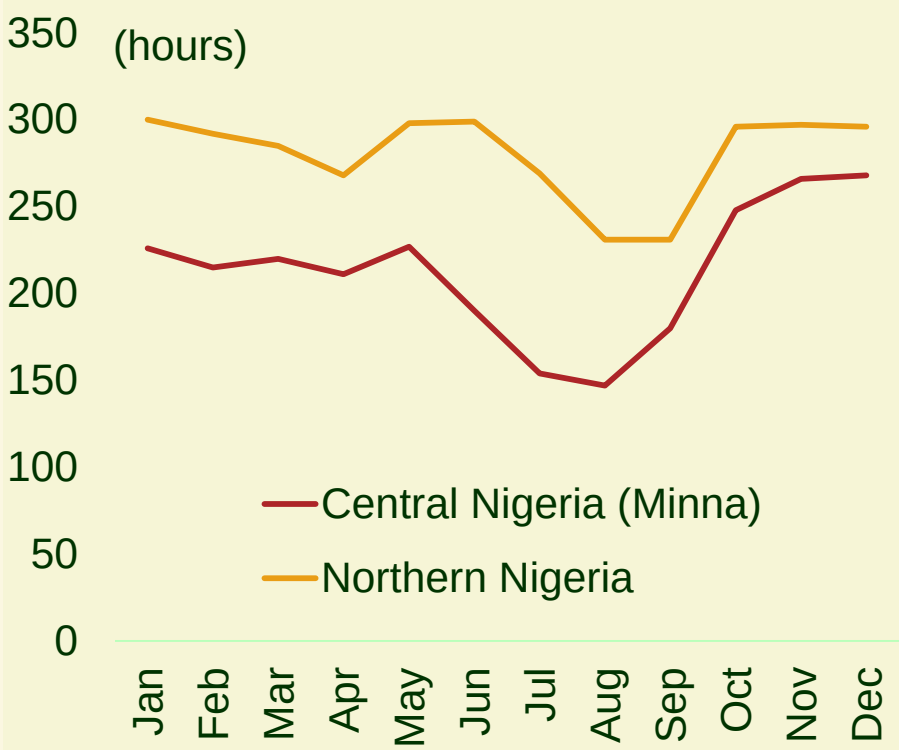


Figure 3. Average monthly hours of sunshine in Central and Northern Nigeria (Birnin Konni – border between Nigeria and Niger)
Source: Assessed from NCDC (2014).

Irrigated rice yield in Nigeria Lower in the South

Fertilizer use and yield	Irrigated Rice				Rainfed Rice		
	North	South	Total		North	South	Total
All inorganic fertilizer (kg / ha)	228	195	215		81	64	67
NPK	113	56	91		51	24	29
Urea	106	138	115		31	29	29
Nitrogen (kg / ha)	70	72	71		22	17	18
Yield (ton / ha)	**3.7**	**2.8**	3.4		1.4	1.6	1.6

Source: Presenters calculations based on the Living Standard Measurement Survey (2010).

Rainfed condition

- South – higher nutrients on top soil than the North

⇒ Less fertilizer is required in the South than in the North

Irrigated condition

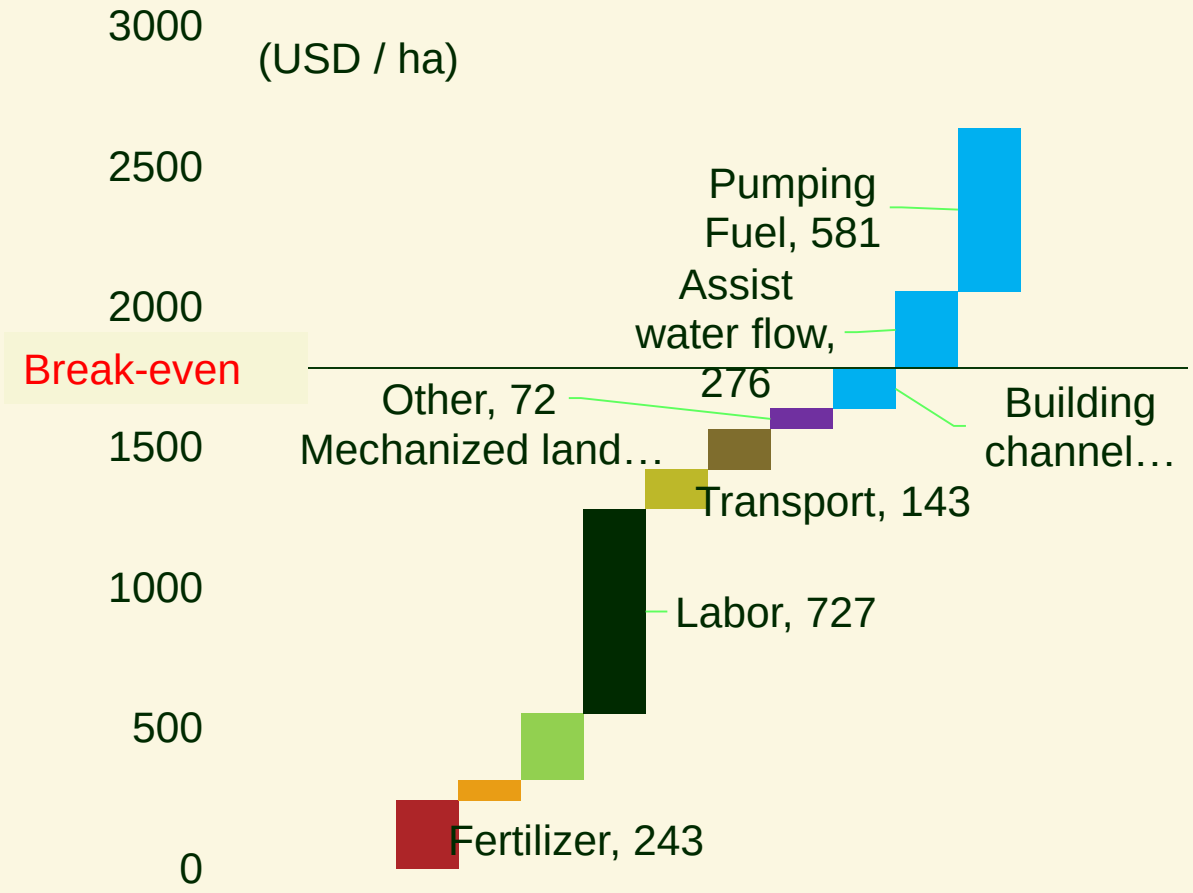
- Further studies needed

Diverted stream common in the North Central and the South

Irrigator types	Major crops irrigated	Key characteristics	%	Main Regions	Water sources	System
1. Labor-intensive diverted stream irrigators	Rice	Small scale, labor abundant with low real wage, better market access	33	NC	Stream	Diverted stream
2. Tractorized irrigators	Rice	Commercial; largest irrigated area, though still small scale; input intensive, with heavy tractor uses	2	SE, NC	Stream	Diverted stream
3. Grains / legumes irrigators	Grains / Legume	Rainy season irrigation, suburban, subsistence, small scale, some intensive use of fertilizer, animal traction	33	NW	Borehole, Stream	Pump (motor, hand)
4. Dry season irrigators	Vegetables (occasionally rice)	Semisubsistence; small scale; intensive use of fertilizer, seed/chemicals, animal traction; relatively labor endowed	33	NE, NW, SW	Stream	Pump (motor)

Source; Typology of irrigators in Nigeria (Takeshima & Edeh 2013).

Rice irrigation in the North Central - Challenges



Without irrigation infrastructure rehabilitation (canal, plot leveling), production is unprofitable

Farm budget of Irrigated Rice Production (Southern Kogi)
Yield = **2.8** t / ha

Vegetable irrigation

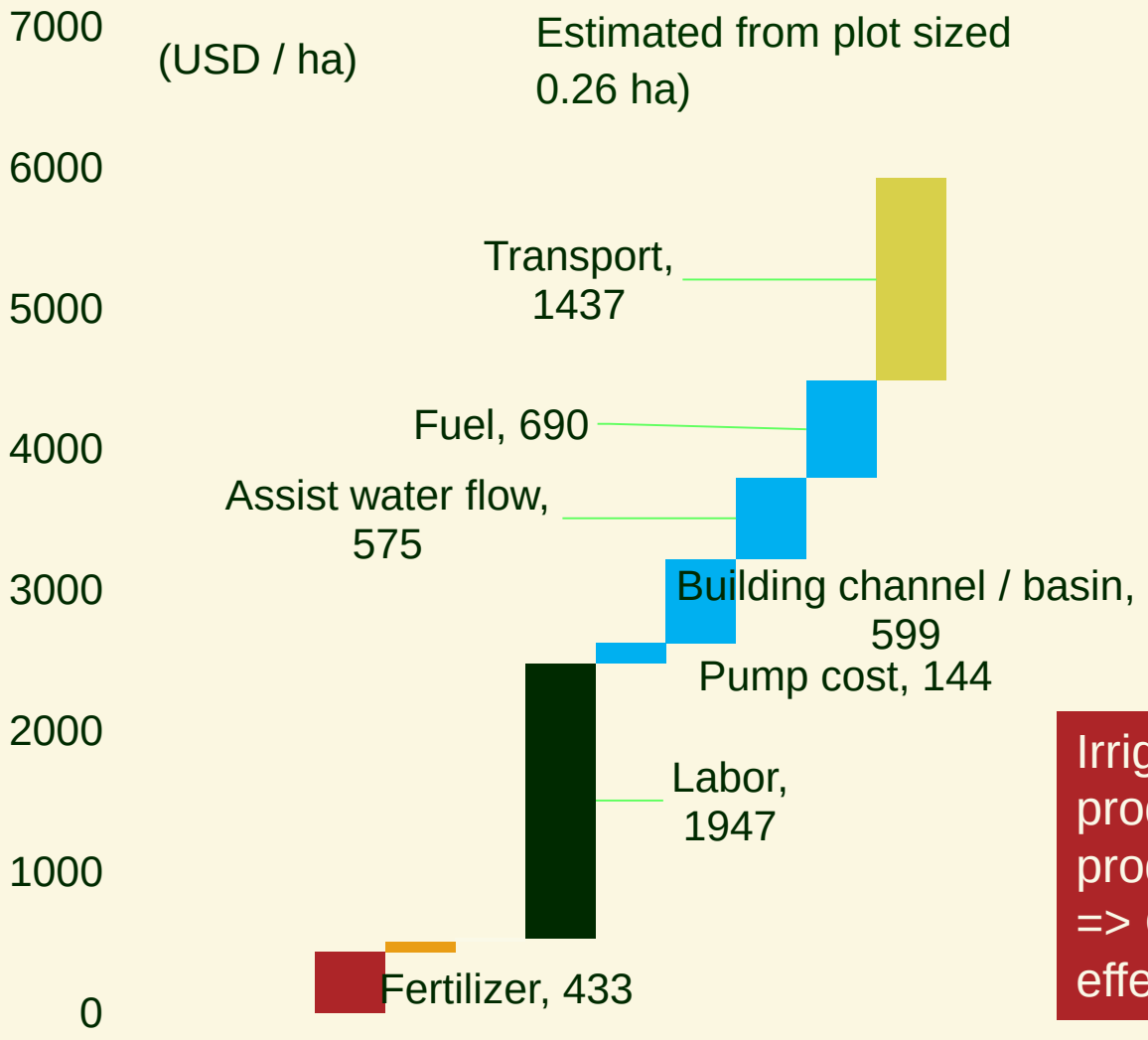
- Okra – example
  - more tolerant to heat than tomato or dry onion in tropical conditions
- Nigeria – 2nd largest producer in the world (after India)
- Mostly produced in the South – unlike other major vegetables (tomato, onion etc)

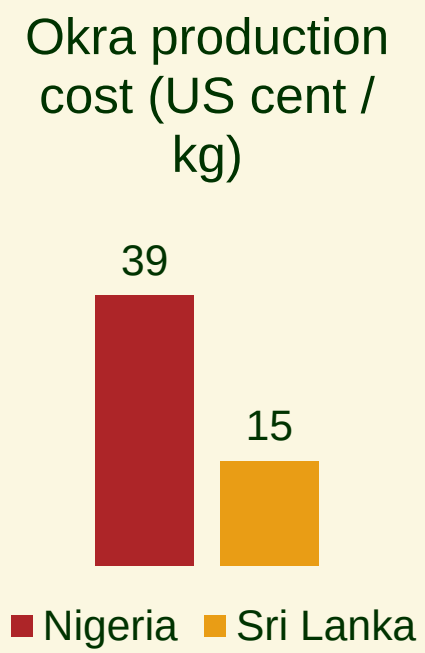
% of all households growing vegetables (2010)

	NE	NW	NC	SE	SS	SW
Okra	2.3	2.9	2.6	8.9	2.8	0.6
Onion	1.1	2.6	0.3	0	0	0.2
Pepper	3.4	5.2	4.1	1.4	1.3	3.6
Tomato	2.2	2.4	2.8	0	0.3	1.7

- USA / India - breeding of okra varieties (Kumar et al. 2010)
- West Africa – importers of these varieties
- Need for breeding for specific environment (Ariyo, 1990; Kumar et al. 2010)

Vegetable irrigation – okra in Kogi state





Irrigated vegetable production is profitable but production cost is high
=> Currently limited poverty effect

Aquaculture – example in Anambra state

- Farmers' investment into earthen ponds for aquaculture
- 40 feet * 20 feet - N40,000, maintained at N10,000 / year
- Various species including catfish, Heterobranchus, clarias
- Dry season: motor pumping from the stream (located adjacent to the pond) - N1000 / week
- Rainy season: no water pumping
- 500 ~ 1000 pieces can be grown in each of this size of pond
- Priced at N1500 ~ 3000 per piece
- Feed - the most expensive cost factor (N1000 ~ 1100 per a piece of fish)

Manual construction of earthen pond

Fish feedstock - one of the most costly components

Women - typically selling fish products from the river

Conclusions

- **Water resources is sufficient in Nigeria to warrant significant investments into agricultural water management**
- **Advantages and disadvantages in irrigation compared to northern Nigeria**
  - **Advantages**
    - Higher rainfall – supplementary irrigation easier
  - **Disadvantages**
    - Lower solar radiation / sunshine – currently lower yield potential
    - Greater constraints in adopting varieties from temperate countries
    - Pump irrigation (high irrigation costs) often uneconomical given the current technologies
- **R&D (plant breeding) and irrigation infrastructure – pre-requisite for successful irrigation expansion**
  - Need varieties that respond well to irrigation, grow well under low solar radiation / sunshine, have tastes that attract consumers
  - Other support for flood recession, dry season irrigation can be more effective if investments into R&D and Irrigation infrastructure are sufficient

Opportunities and challenges

- Institutional innovations
  - Collective actions on water resource management
  - Farmers' own innovations – more studies needed
- Market failure
  - Credit constraints
  - Irrigation equipment markets
- Pro-poorness, gender equality
  - Complicated pathway
    - Direct benefits vs spill-over?
    - Intra-household resource allocations
    - Persistent gender-division (men – cash crop, farming; women – food crop, marketing, etc)

Selected References

Aluwihare PB & M Kikuchi. (1991). *Irrigation investment trends in Sri Lanka: New construction and beyond.* Colombo, Sri Lanka. IWMI.

Ariyo OJ (1990). Variation and heritability of fifteen characters on okra (Abelmoschus esculentus (L.) Moench). *Tropical Agriculture 67*, 213-216.

Foster V & N Pushak. (2011). *Nigeria's Infrastructure: A Continental Perspective.* IBRD / World Bank. Washington, DC.

Goldman A & J Smith. (1995). Agricultural transformations in India and Northern Nigeria: Exploring the nature of green revolutions. *World Development 23*(2), 243-263.

Jaroensathapornkul J. (2007). The Economic Impact of Public Rice Research in Thailand. *Chulalongkon Journal of Economics 19*(2), 111-134.

Kikuchi M & PB Aluwihare. (1990). *Fertilizer response functions of rice in Sri Lanka: Estimation and some applications.* International Water Management Institute. Colombo, Sri Lanka.

Kikuchi M, A Maruyama & Y Hayami. (2003). Phases of irrigation development in Asian tropics: A case study of the Philippines and Sri Lanka. *J. Devel. Stud. 39*(5), 109–138.

Kumar S, S Dagnoko, A Haougui, A Ratnadass, D Pasternak & C Kouame. (2010). Okra (Abelmoschus spp.) in West and Central Africa: Potential and progress on its improvement. *African Journal of Agricultural Research 5*(25), 3590-3598.

MacDonald, A M, H C Bonsor, B É Ó, Dochartaigh and R G Taylor. (2012). Quantitative maps of groundwater resources in Africa. *Environmental Research Letters 7*(2), 1–7.

References

NCDC (National Climatic Data Center)(2014). *Monthly Climatic Data for the World.* Available at http://www.ncdc.noaa.gov/IPS/mcdw/mcdw.html.

Pagiola S, R Martin-Hurtado, P Shyamsundar, M Mani & P Silva. (2002). *Generating public sector resources to finance sustainable development: Revenue and incentive effects.* World Bank. Washington, DC.

Pradhan P. (1993). *4. Research priority of irrigation management in Nigeria.* In *Irrigation research priorities for Nigeria: Proceedings of a National seminar held at the University of Ilorin, Nigeria from 20 to 23 April, 1993*, Nwa EU & P Pradhan (eds.).International Irrigation Management Institute, Kano, Nigeria.

Rosegrant M & E Pasandaran. (1993). *Determinants of public investment: Irrigation in Indonesia.* Paper presented to the 37th annual conference, Australian Agricultural Economics Society, University of Sydney, 9-11, February 1993.

Takeshima H & H Edeh. (2013). *Typology of Farm Household and Irrigation Systems Some Evidence from Nigeria.* IFPRI Discussion Paper 01267.

Takeshima H & F Yamauchi. (2012). Risks and farmers' investment in productive assets in Nigeria. *Agricultural Economics 43*(2), 143–153.

Thakkar H. (1999). *Assessment of Irrigation in India*. Contributed paper prepared for Thematic Review IV.2 for the World Commission on Dams.

Thomas D & W Adams. (1999). Adapting to dams: agrarian change downstream of the Tiga Dam, northern Nigeria. *World Development 27*(6), 919-935.

You L, C Ringler, U Wood-Sichra, R Robertson, S Wood, T Zhu, G Nelson, Z Guo & Y Sun. (2011). What is the irrigation potential for Africa? A combined biophysical and socioeconomic approach. *Food Policy 36*(6), 770-782.