Water Saving Technology Adoption in Northern China

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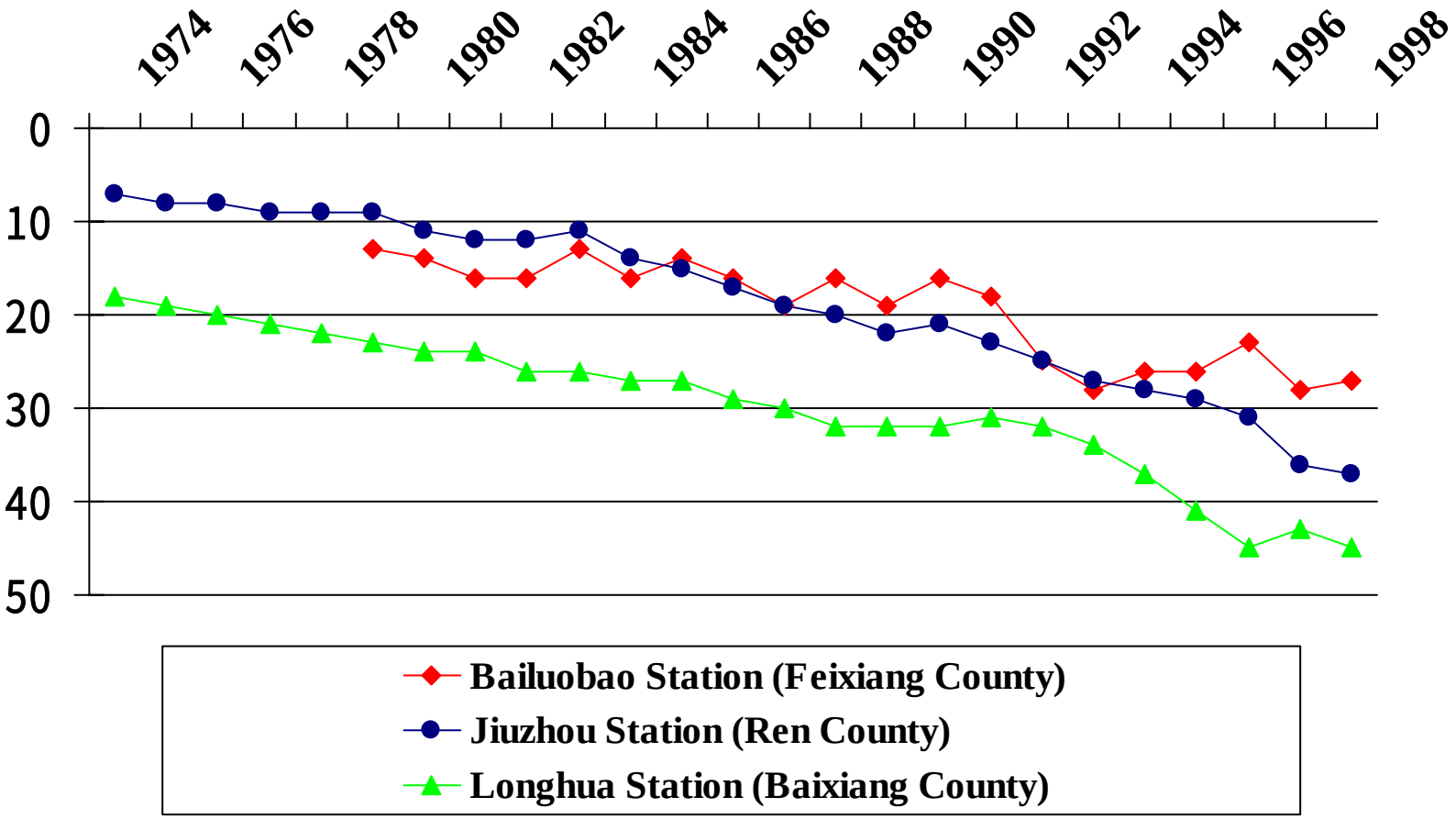
Northern China's Water Shortage

- Falling Supply
  - Rapidly falling groundwater levels
  - Historically low surface supplies
- Rising Demand
  - Urban and Industrial
  - Agricultural

"*Saving Water, Saves Lives*"

Hebei: Falling Shallow GW Table



Deep water table depth to water (1980-98)
Fuyang River Basin – Selected Counties

County/City	Decline (m/year)
Longrao County	2.24
Pingxiang County	2.18
Xingtai City	1.97
Jiuzhou County	1.86
Wuyi County	2.18
Wuqiang County	2.20

China is facing a water crisis

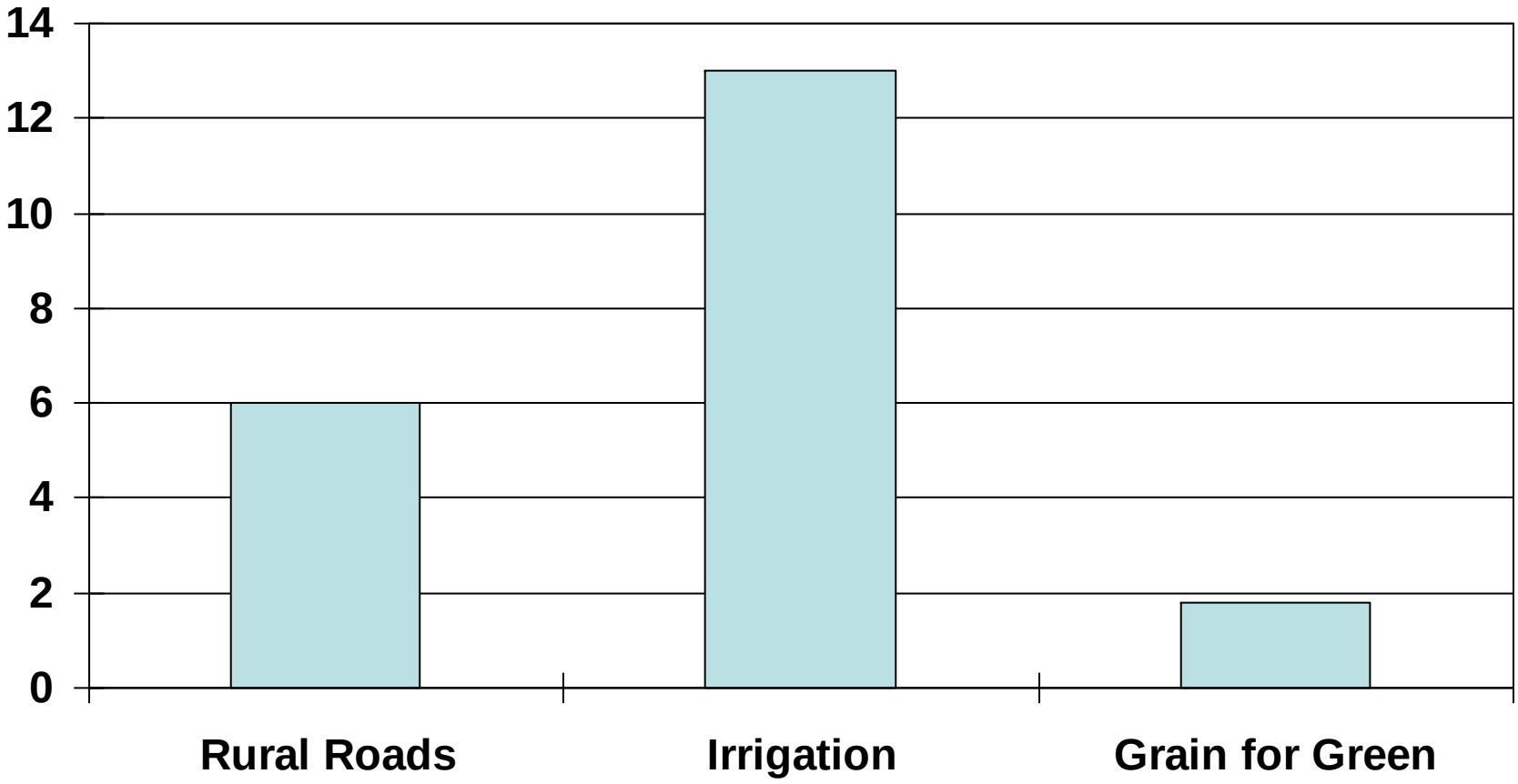
- At least that is the perception of many scholars and policy makers
  - Senior agricultural and water policy officials claim that water shortages pose the largest challenge to China's agricultural sector in the 21st century

- Scholars – inside and outside of China – disagree about the severity of the problem:
  - One side: Will fundamentally affect China's future food supply
  - Other side: Serious, but can be addressed by economically sound policies that provide the "correct" incentives to water users

Water Conservation Policy efforts -- less than successful

- Policies :
  - Pushing **water charges**
  - Establishing **water rights**
  - Encouraging **farmer participation**
  - Other **institutional reforms**
- Not much progress / many constraints
- However, national and local governments continue to pour resources into the development of water resources

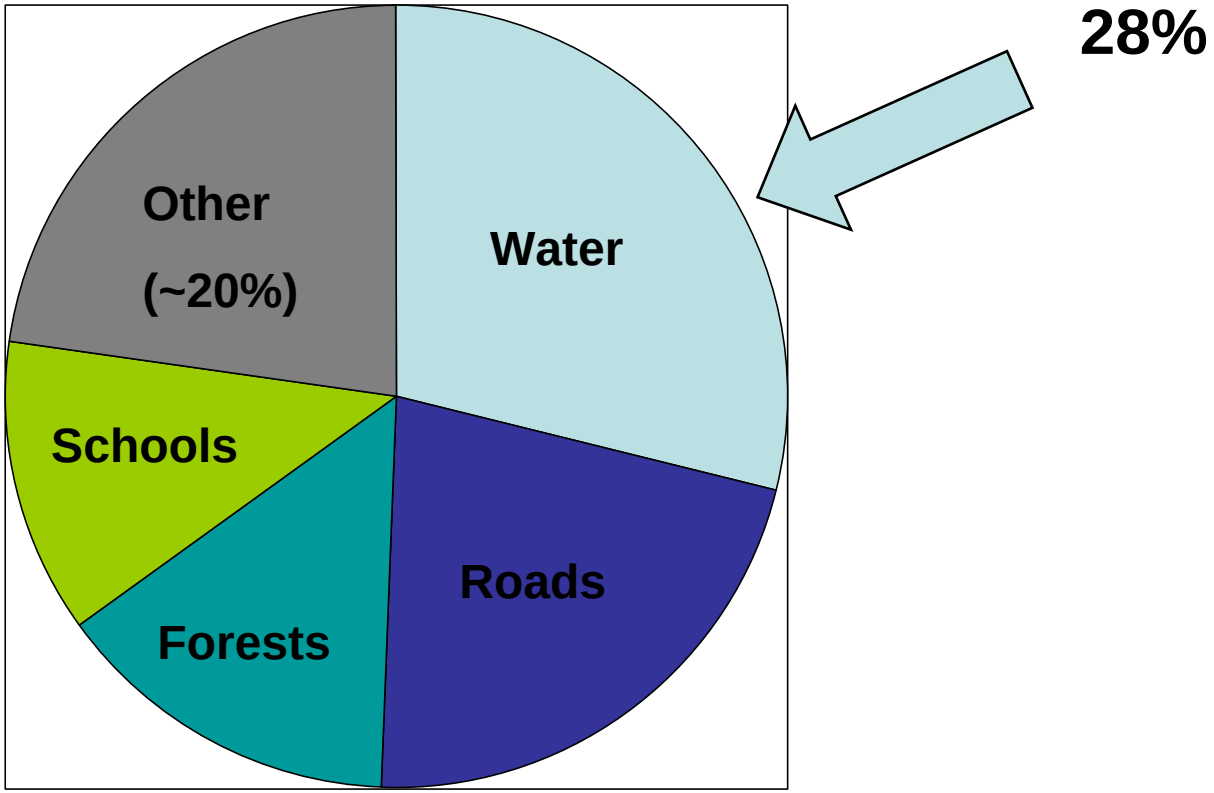
Total "Budgeted Investment" for Public Goods in Rural China ($US Billion —PPP terms)



Sources: Huang, 2002; Fan, Zhang and Zhang, 2004；Xu and Cao, 2002 (Statistical Yearbooks)

Public Good Investment in China's villages

(by villagers and/or higher levels of government)



Growing Consensus that a New, More Focused Effort is Needed

- "Everyone in the government is pushing me to allocate more money to the agricultural sector, generally, and to water resources in particular …"
- "My feeling is that water-saving technology is one area that has great potential for addressing China's water problems and helping farmers increase production and income …"
- "But, I know almost nothing about the state of China's water saving technology: How much is there? Who is adopting? How much effect have government programs in the past made?"

"If I knew water saving technology worked and if I knew where an investment would have the most effect, I would allocate up to a quarter of my budget to this one activity!"

Du Ying, Director of the Agricultural Division, Development and Reform Commission, Beijing, August 30, 2004

Goals and Objectives

- Overall goal: answer some of Du Ying's questions on water saving technology:

- Specific goals of this presentation:
  - Lay out the first order facts on water saving technology
    - What is being adopted?
    - What are the trends?
    - What is the motivation?
    - Is there a perception that water is being saved?
  - Begin to understand the factors that induce some households / villages to adopt and others not to (focusing on resource scarcities which may affect incentives and extension efforts that may help overcome information problems)

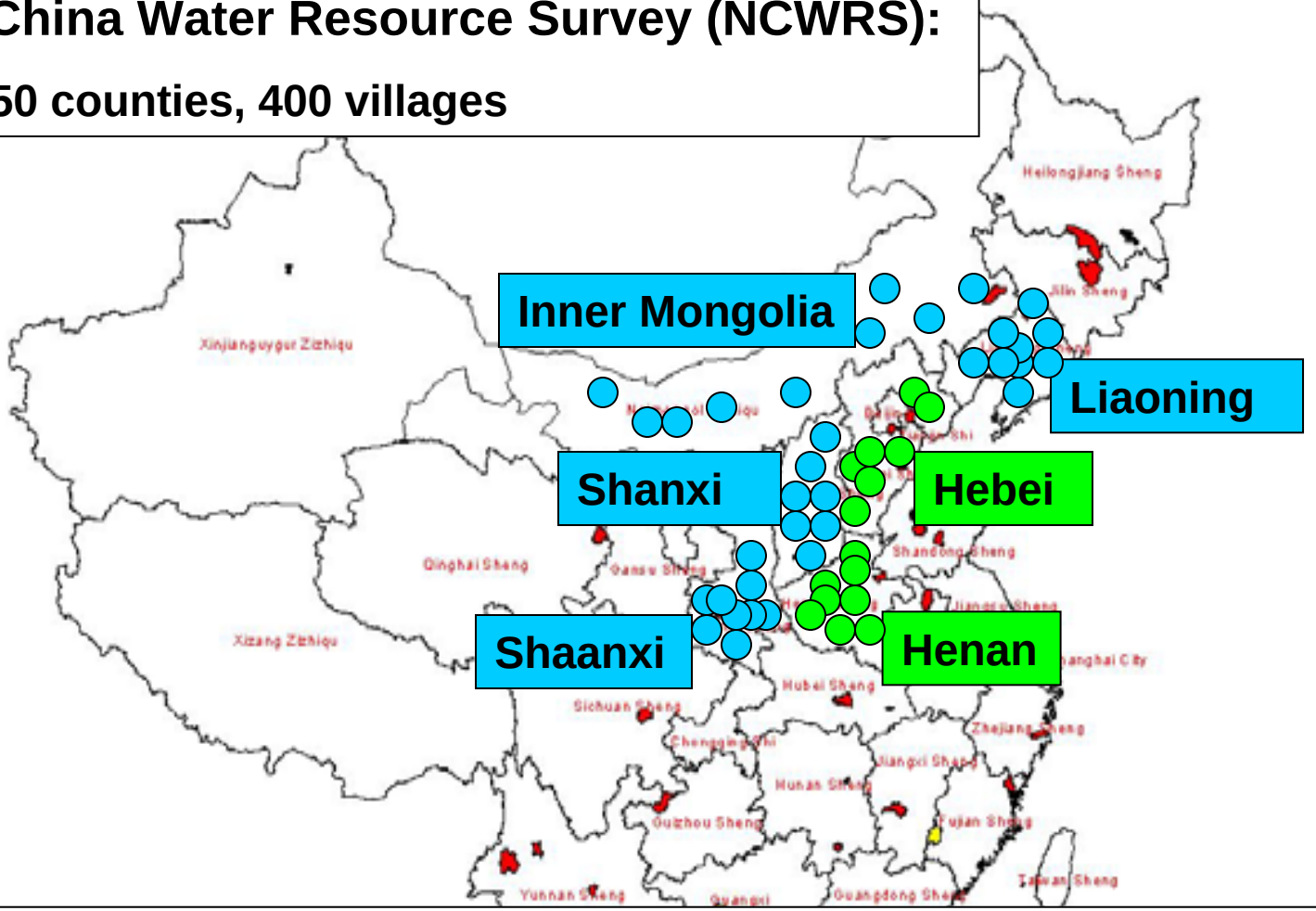
Data

- Collected by ourselves over the past 3 years
- Most recent survey was designed to be representative of northern China—all provinces north of the Huai River—*huabei* (North China); *xibei* (Northwest China) and *dongbei* (Northeast China)
- We use population-based weights for all of our descriptive statistics … This allows us to construct point estimates of water resources and institutions in northern China
- Sponsored by IWMI and ACIAR

Data set 1:

2004 North China Water Resource Survey (NCWRS):

6 provinces, 50 counties, 400 villages



Data set 2:

2001/2004 China Water Institutions and Management (CWIM) Panel

2 provinces, 9 counties, 48 villages

(village leaders, groundwater managers, surface water managers, & farm households)

Content of Survey

- **Socio-economic characteristics**
- **Resource base (water & land)**
- **Water Institutions:**
- **Agricultural production and irrigation practices**
  - **Management and fees**
  - **Property rights (wells and pumps)**
- **Water quality**
- **Water saving technology**
- **Well, pump and other irrigation investment**

Projects / Papers

1. Evolution of Water Resources and Impacts on Institutions Agriculture and Incomes
2. Northern China's Changing Water Use and Cropping Patterns
3. Water Demand: Price elasticities and willingness to pay
4. Water Saving Technology
5. Institutions
6. Water Markets
7. Water Quality
8. Conjunctive Use
9. Pump/Well adoption and investment

Water Saving Technologies

- **“Traditional”**

  Land leveling; Border Irrigation; Furrow Irrigation
- **“Household-based”**

  Plastic sheeting; Drought resistant varieties;

  Surface hose delivery (“white dragons”); Retained stubble/No-till
- **“Community-based”**

  Lined Canals; Sprinklers; Underground pipe networks
- **“Novel/infant”**

  e.g., drip irrigation (but at household and village level, less than 1% level of adoption)

Traditional Technologies

- Level Fields
- Border Irrigation
- Furrow Irrigation

- Common practice
- Traditional (pre 1949)

Community-Based Technologies

- Underground Pipe
- Lined Canals
- Sprinklers

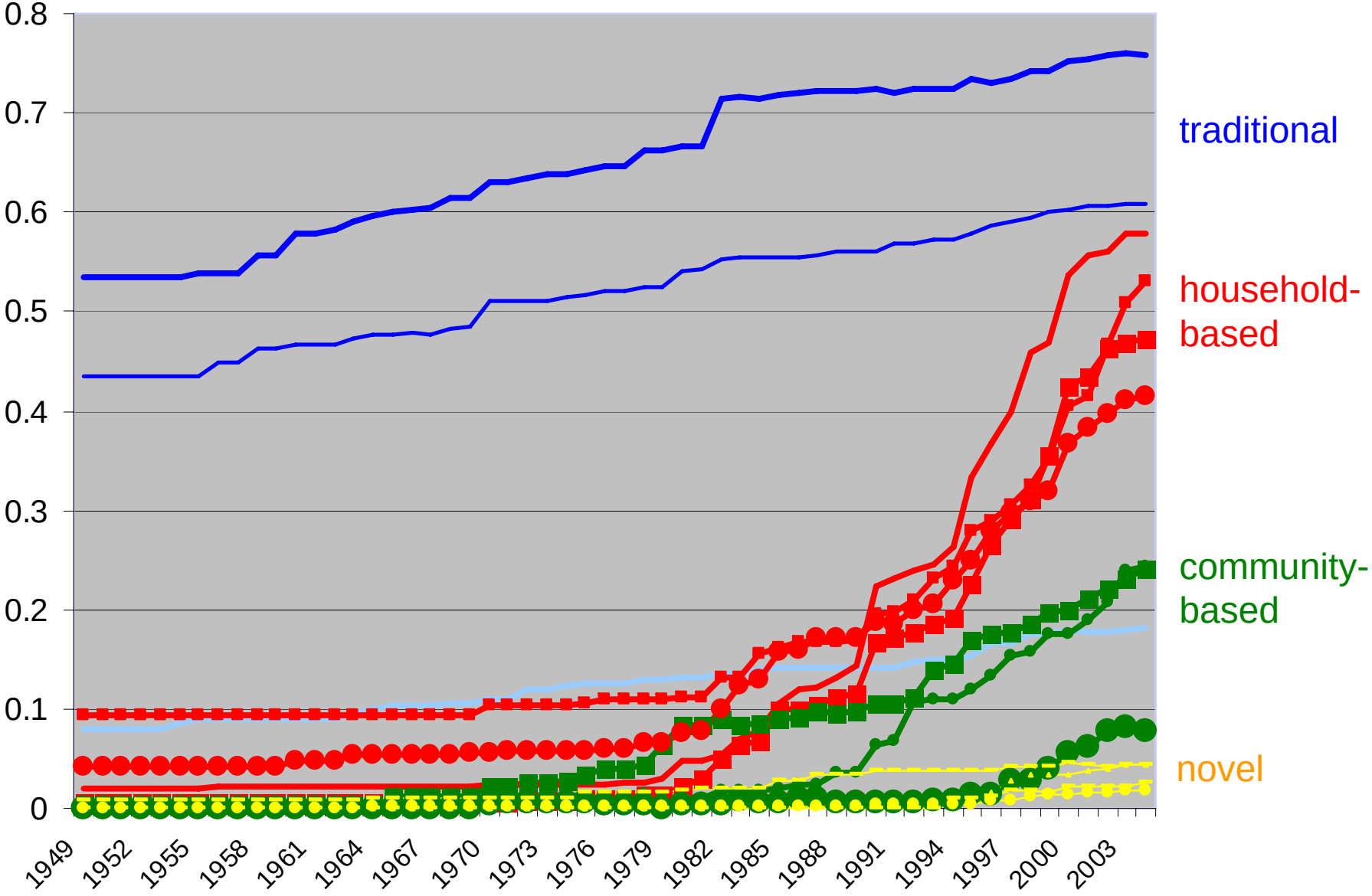
- High Fixed Costs
- Adoption decision often made by government, village or group of households
- Collective action

Household Technologies

- Plastic Sheeting
- Surface Pipe (white dragon)
- Drought Resistant Varieties
- Retain Stubble / No Till

- Low Fixed Costs
- Adopted by households
- Highly divisible

Adoption of Water Saving Technologies in Northern China, 1949 to 2004

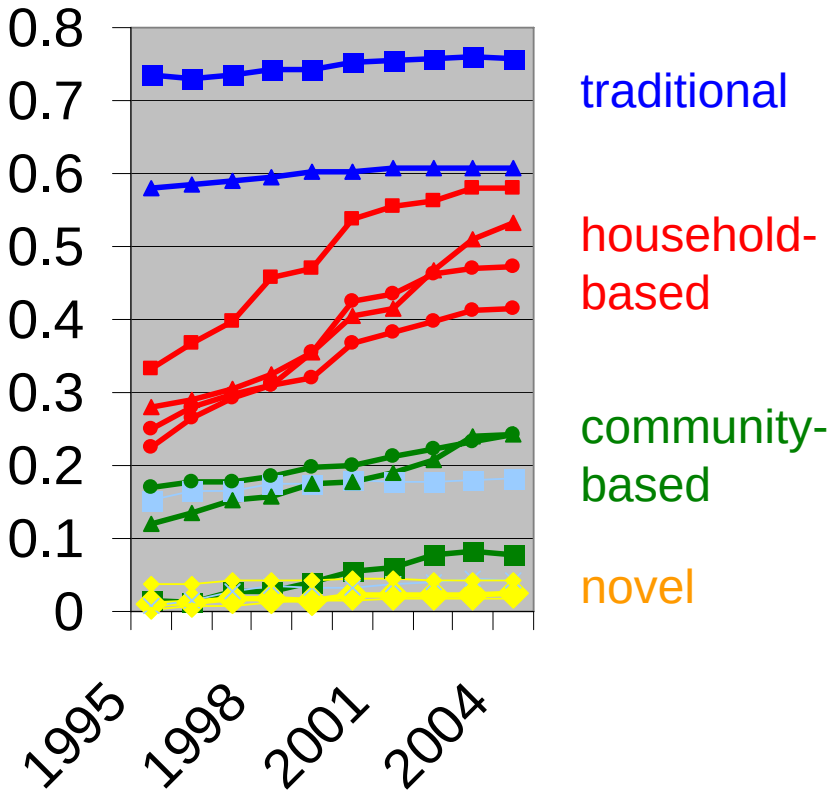


Technology Adoption by Percentage of Sown Area

Technology	n	1995 Mean % of Sown Area	2004 Mean % of Sown Area	Growth	Growth Rate
Traditional Technologies:					
Level Fields	441	33%	39%	6%	18%
Border Irrigation	441	24%	32%	7%	30%
Furrow Irrigation	443	4%	5%	1%	34%
Household-Based Technologies:					
Surface Pipes (Bai Long)	441	7%	16%	9%	140%
Plastic Ground Cover Film	441	5%	11%	6%	116%
Retain Stubble / No Till	441	8%	20%	12%	138%
Drought Resistant Varieties	442	10%	17%	7%	63%
Community-Based Technologies:					
Underground Pipe	444	4%	11%	8%	200%
Lined Irrigation Canals	442	4%	8%	4%	103%
Sprinklers	443	0%	3%	2%	3140%

Water saving technology after 1995 – both households and villages

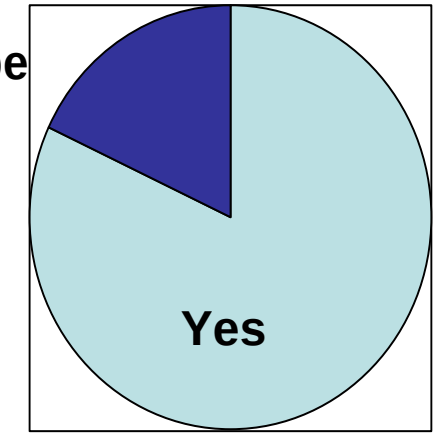
- **Traditional**: begins at high levels of adoption / slow growth
- **Household-based:** begins fairly low / grows rapidly
- **Community-based:** begins very low / grows steadily / ends fairly low



Adopted to Save Water?

Surface Pipe

82 %

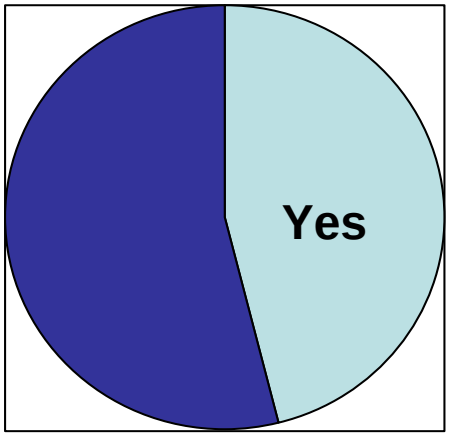


Plastic Film

46 %

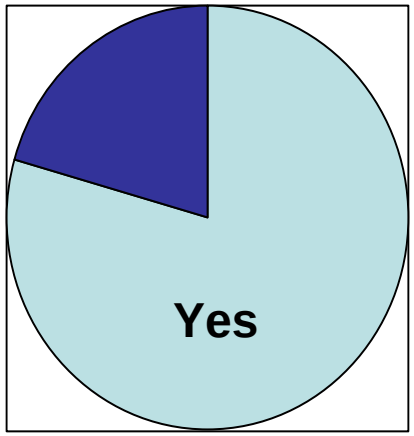
Other Reasons:

Temperature & Yield



Drought Resistant Varieties

70 %

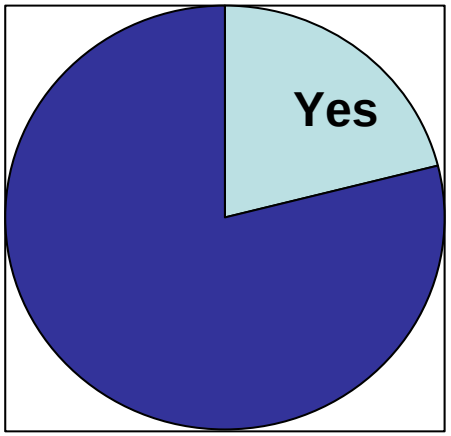


Retain Stubble / No Till

21 %

Other Reasons:

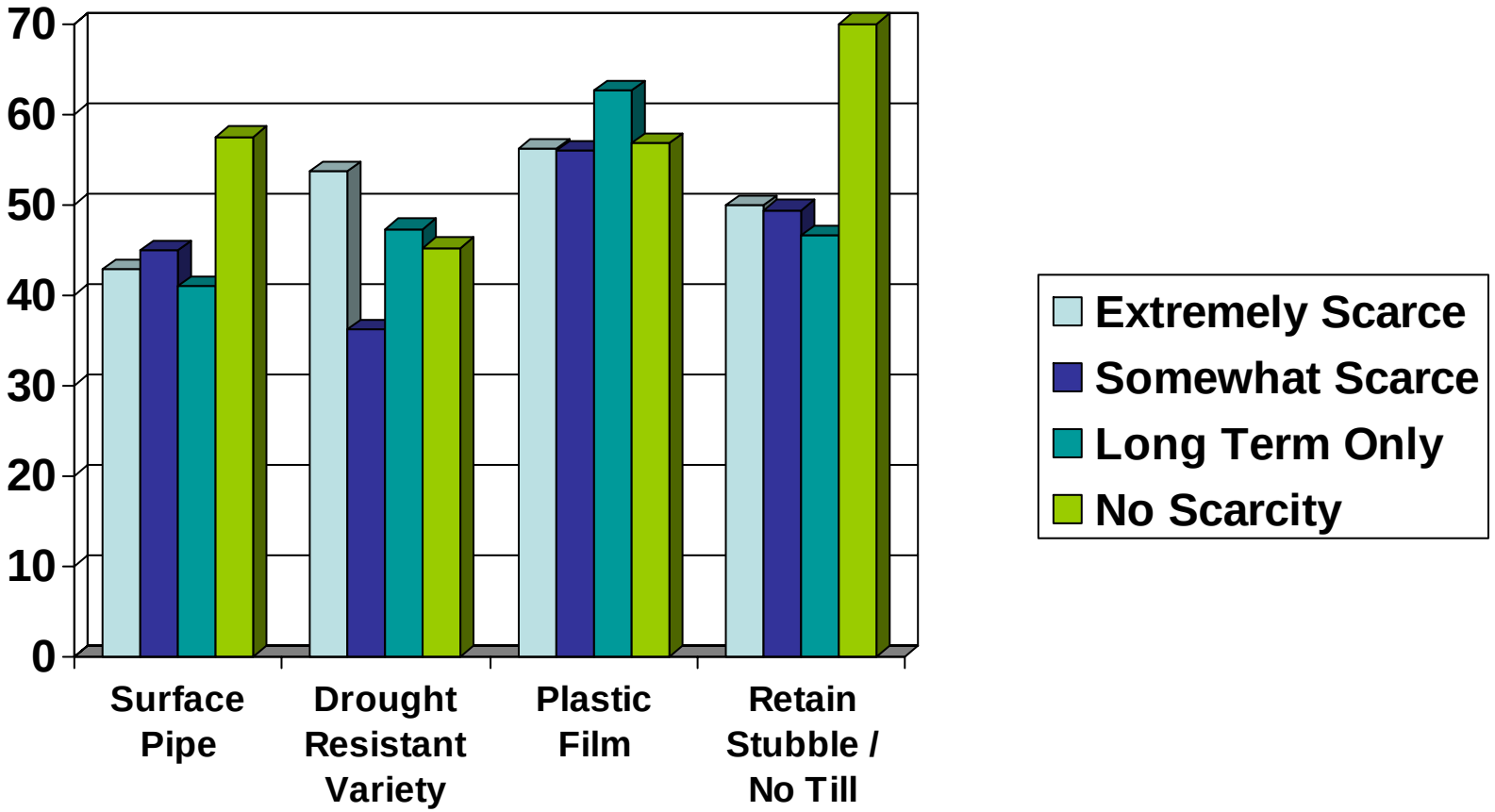
Fertilizer & Yield



Village Leader Estimates of Water Savings

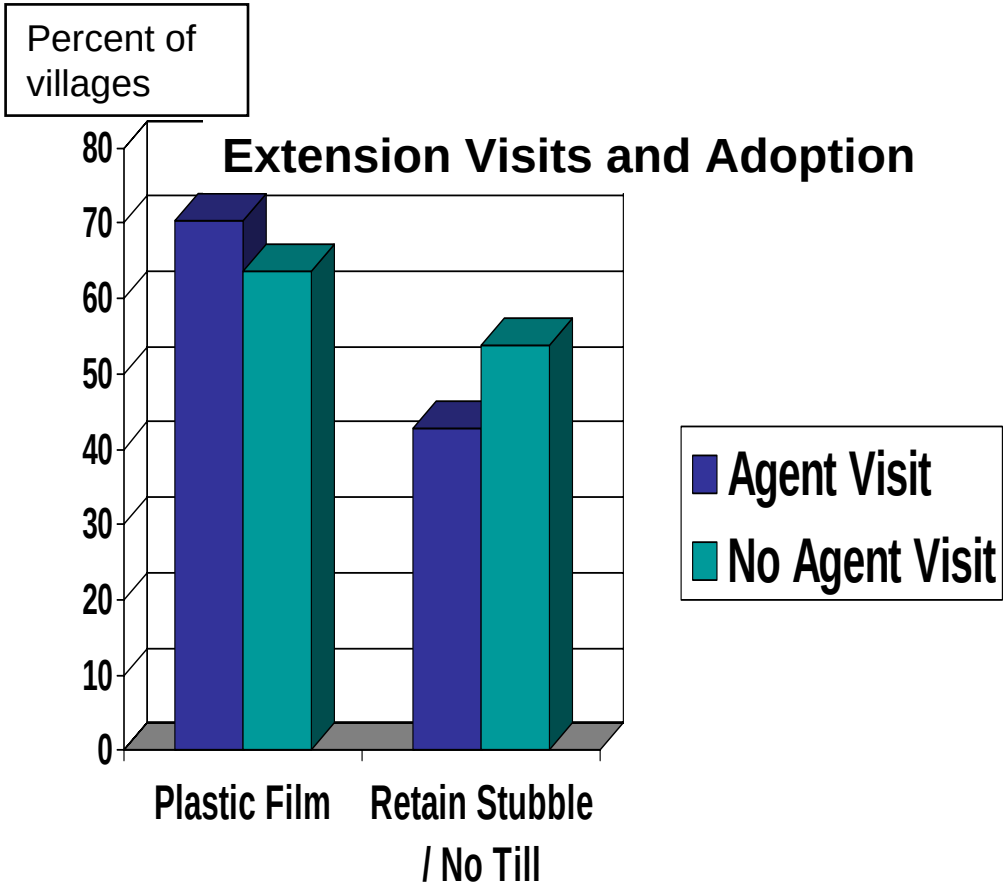
- Surface Pipe: 46%
- Drought Resistant Varieties: 33%
- Plastic Film: 51%
- Retain Stubble / No Till: 46%

Is Adoption a Response to Water Scarcity?



Is Adoption a Response to Extension?

Extension Activities promoting water saving technology (Proportion of villages)	
Agent Visits	**(35%)**
Directive	**(39%)**
Meeting	**(65%)**
Model Village	**(26%)**



Hypotheses

- Induced technological change:
  - As water becomes more scarce, farmers will move to adopt technology to conserve the scarce resource
    - But, there are caveats:
      1. there are incentives to save water
      2. there are appropriate technologies to adopt
      3. the technology is affordable …
      4. the increasing relative scarcity of other factors of production (e.g., labor) that are increasing faster (i.e., the wage may be rising faster than the price of water) might offset the propensity to adopt water saving technology
- Information acquisition is costly
  - Extension activity may lower these costs, encouraging adoption

Household Plot Regressions

```
Probit estimates                                  Number of obs   =        523
                                                  LR chi2(21)     =      84.80
                                                  Prob > chi2     =     0.0000
Log likelihood = -312.84362                       Pseudo R2       =     0.1194
------------------------------------------------------------------------------
 SurfacePipe |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         age |  -.0237948   .0075881    -3.14   0.002    -.0386673   -.0089223
         edu |  -.0490602   .0217178    -2.26   0.024    -.0916262   -.0064942
    Distance |   .2413324   .1058859     2.28   0.023     .0337999    .4488649
          mu |   .0346551   .0375907     0.92   0.357    -.0390212    .1083315
        Sand |   -.299339   .1569391    -1.91   0.056     -.606934    .0082559
        Loam |  -.3140469   .1575306    -1.99   0.046    -.6228012   -.0052926
       Hills |  -.4764578   .2552857    -1.87   0.062    -.9768086     .023893
     LowHill |   .0185903    .306642     0.06   0.952    -.5824169    .6195976
  LowQuality |  -.3111828   .2283586    -1.36   0.173    -.7587574    .1363917
  MedQuality |   .0246801   .1310848     0.19   0.851    -.2322415    .2816017
      NoIrri |  -.2792362   .2947934    -0.95   0.344    -.8570207    .2985483
          SW |  -.5793921   .1753632    -3.30   0.001    -.9230977   -.2356864
        SWGW |  -.1259745   .1713172    -0.74   0.462    -.4617501    .2098011
       y2004 |   .2557671   .1219509     2.10   0.036     .0167477    .4947865
       Henan |    .133611   .1716746     0.78   0.436     -.202865    .4700869
VlgWatStat~1 |  -.6998319   .2583857    -2.71   0.007    -1.206259   -.1934052
VlgWatStat~2 |   .6716806   .2083625     3.22   0.001     .2632976    1.080064
       Agent |    .702428   .2189035     3.21   0.001      .273385    1.131471
     WenJian |   .0095544   .2379622     0.04   0.968    -.4568429    .4759517
     Meeting |  -.2698278   .1481938    -1.82   0.069    -.5602822    .0206266
    ModelVlg |  -.3404527   .2900623    -1.17   0.241    -.9089644     .228059
       _cons |   1.149498   .4308274     2.67   0.008     .3050921    1.993904
------------------------------------------------------------------------------
```

Dependent variable:

Plot adoption of household-based water saving technology:

4 sets of independent variables:

1. Water scarcity
2. Extension
3. Plot characteristics
4. Household characteristics

N=523, plot level obs.

Probit

Summary of Scarcity Coefficients

Dependent Variable: Plot Technology Adoption (0=No, 1=Yes)

	Surface Pipes	Drought Resistant Varieties	Plastic Sheeting	Retain Stubble / No Till
Extremely Scarce	-0.70	0.68**	N.A. 1 predicts failure perfectly	0.05
Somewhat Scarce	0.67***	-0.35	0.39	1.39***

** significant at 5%; *** significant at 1% Omitted Variable: No Water Scarcity

Summary of Extension Coefficients

Dependent Variable: Plot Technology Adoption (0=No, 1=Yes)

	Surface Pipes	Drought Resistant Varieties	Plastic Sheeting	Retain Stubble / No Till
Agent Visit	0.70***	-0.17	0.82	-0.38
Directive	0.01	-0.18	-0.94	-0.88***
Meeting	-0.27	0.28	0.30	-0.43***
Model Village	-0.34	-0.30	1.27***	-0.39

** significant at 5%; *** significant at 1%

Conclusions

- Water saving technology is being adopted in increasing amounts. However, many technologies are adopted at low levels.
- Government extension appears to be effective for some technologies, but may involve conflicts of interest for others.
- The link between water scarcity and household adoption appears to be weak, at best. More work is needed to better identify these links. Our current work suggests that some technologies may not be appropriate or that incentive problems hinder adoption.
- Should Du Ying invest a quarter of his budget in water saving technology? There may be scope for expanding extension or developing new, more appropriate, technologies.