The economic value of germplasm and crop improvement as a climate change adaptation strategy:

Samoa and Vanuatu case studies

Impact of future climate extremes on Pacific island agriculture

- Extreme climatic events will threaten the food security and economic wellbeing of **rural households**
- Major negative impacts on **already fragile economies**
- **Risk management**: important that Pacific islands farmers be given the best **opportunity** to be able to adapt to these extremes

The challenge: vulnerability of traditional Pacific island root crops

- Despite strength of traditional Pacific island crops and cropping systems in dealing with risk and disasters, there is an underlying vulnerability due to narrow genetic base

- Most taro grown across the Pacific originated in Melanesia - this makes these root crops particularly susceptible to the impact of diseases (e.g. taro leaf blight)

Climate change increases the **inherent vulnerability** of traditional Pacific island root crops to diseases such as taro leaf blight

Premise of the study:

By enabling farmers to adapt to climate extremes in the medium term, future generations of farmers will be better placed to adapt to climate change

Two case studies

- Utilising regional and national germplasm collections as a reactive climate change adaptation strategy: the case study of taro leaf blight in Samoa

- Broadening the genetic base of root crops as proactive climate change adaptation strategy: The Vanuatu case study

Different approaches to conservation/crop improvement + disaster management

Samoa study demonstrates how crop conservation utilising regional gene bank coupled with an in-country breeding and distribution program provides a basis for an effective response to a biological disaster

Vanuatu study demonstrates a proactive approach where crop conservation, (ex situ and in situ) is used to enhance the diversity of the gene pool - providing the farmers with '**genetic insurance**' to manage climatic variability and future biological disasters

Samoa case study:

A BCA of a program that is a reactive response to climate change

Taro leaf blight resistant crop improvement

What is taro leaf blight (TLB)?

- **Fungal disease** which prefers high night time temperatures and relative humidity
- Disease destroys the taro plants functional leaves
- **Traditional Samoan variety** (taro Niue or Tausala ni Samoa in Fiji) is **highly susceptible**

Impact of TLB on Samoa

- Disease first detected in Samoa in 1993, when it rapidly spread across Upolu and Savai'i
- TLB was an epidemic that destroyed Samoa's most important subsistence crop and export earner

Quantifying the food security and economic impact of TLB

Quantifiable impacts

- domestic taro consumption and increased grain imports
- taro exports

No readily quantifiable impacts

- nutrition

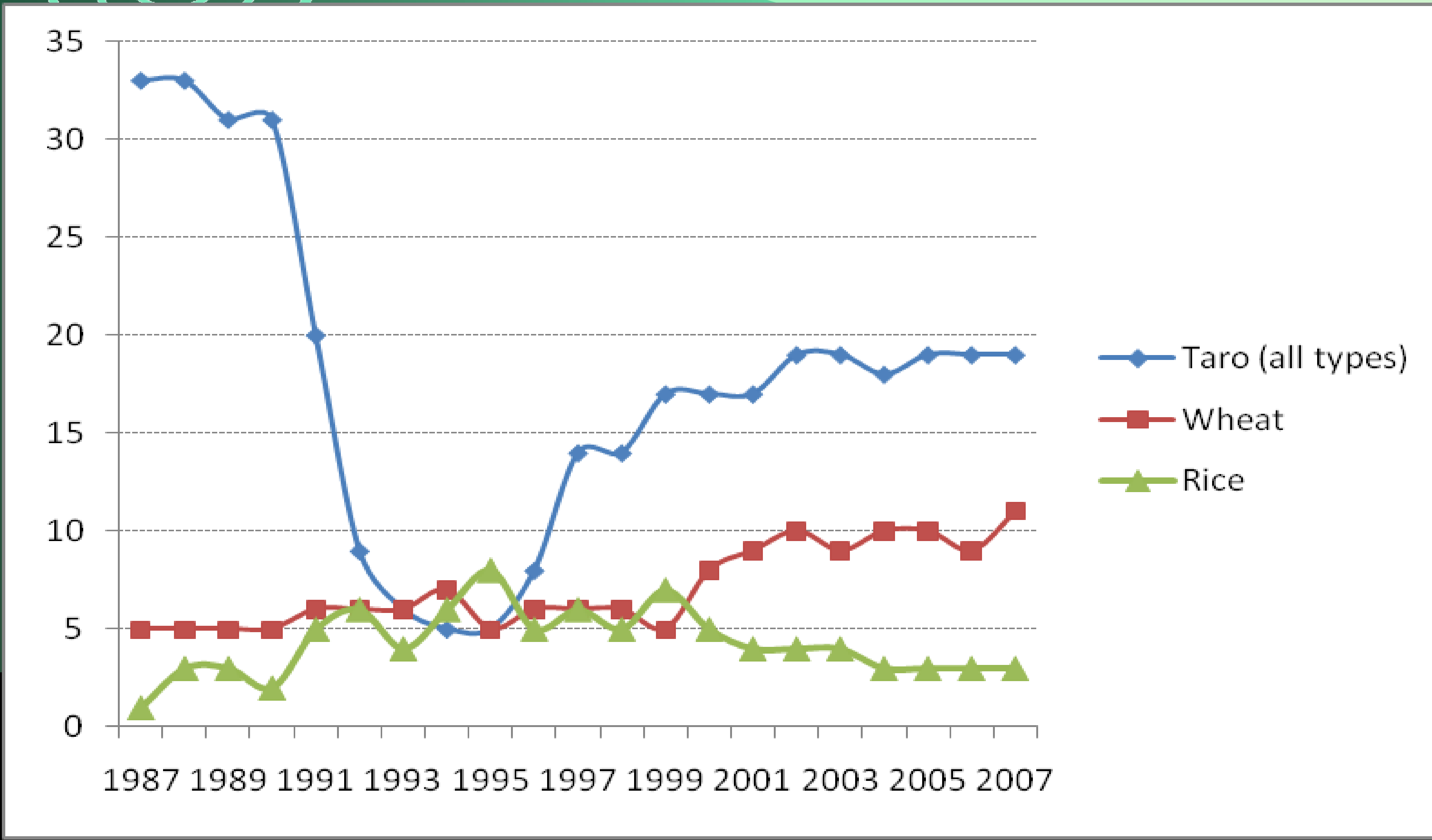
Decreased taro consumption and increased grain imports

FAO Food Balance Sheets show dramatic impact that TLB had on taro production and consumption:

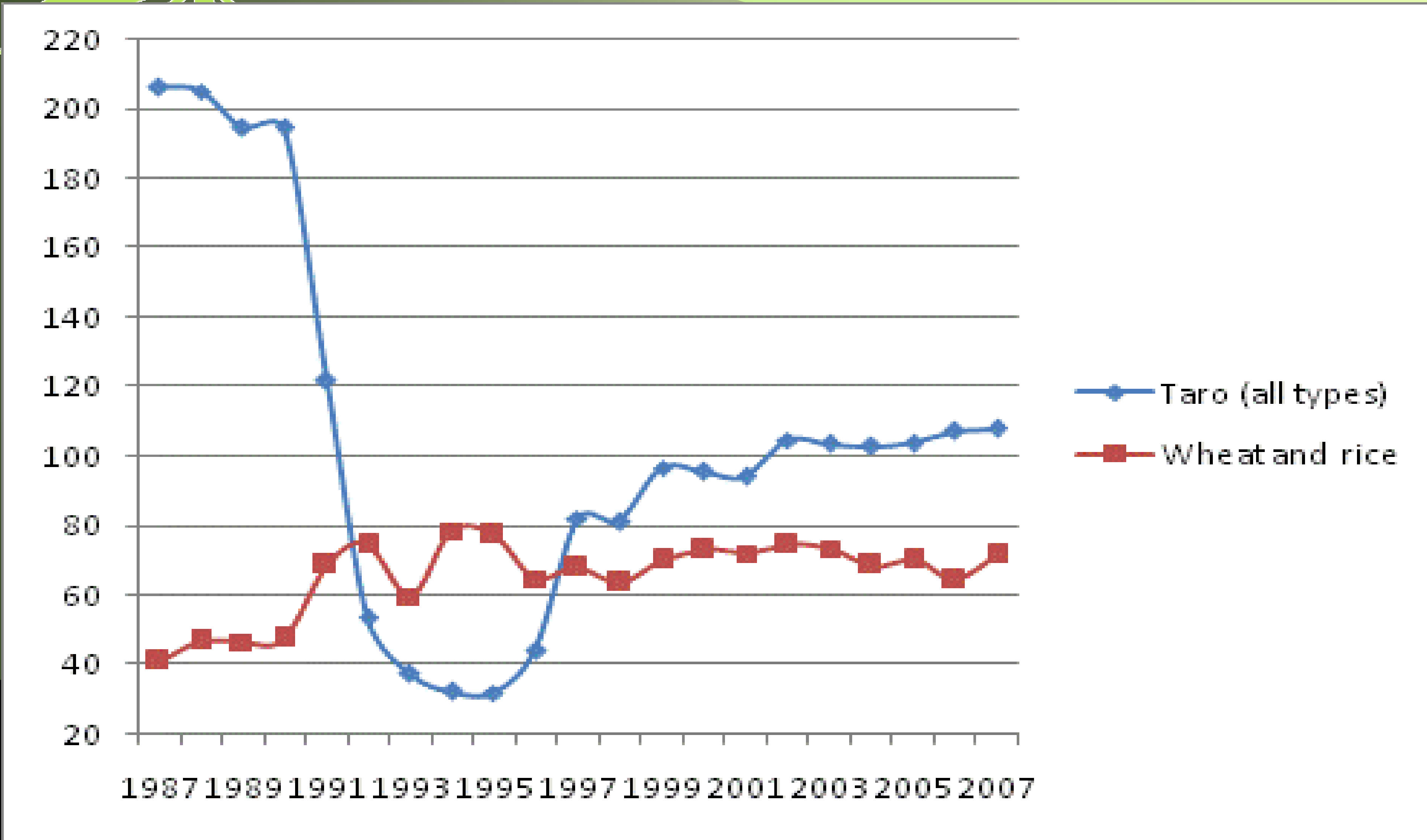
1989 FBS shows:

- 19,460 tonnes of taro was consumed annually - 194.6kgs taro/person/annum, which provided 422 kcal/person/day
- 5,000 tonnes of imported wheat and 3,000 tonnes of imported rice annually - 46.6 kg taro/person which provided 383 kcal/person/day

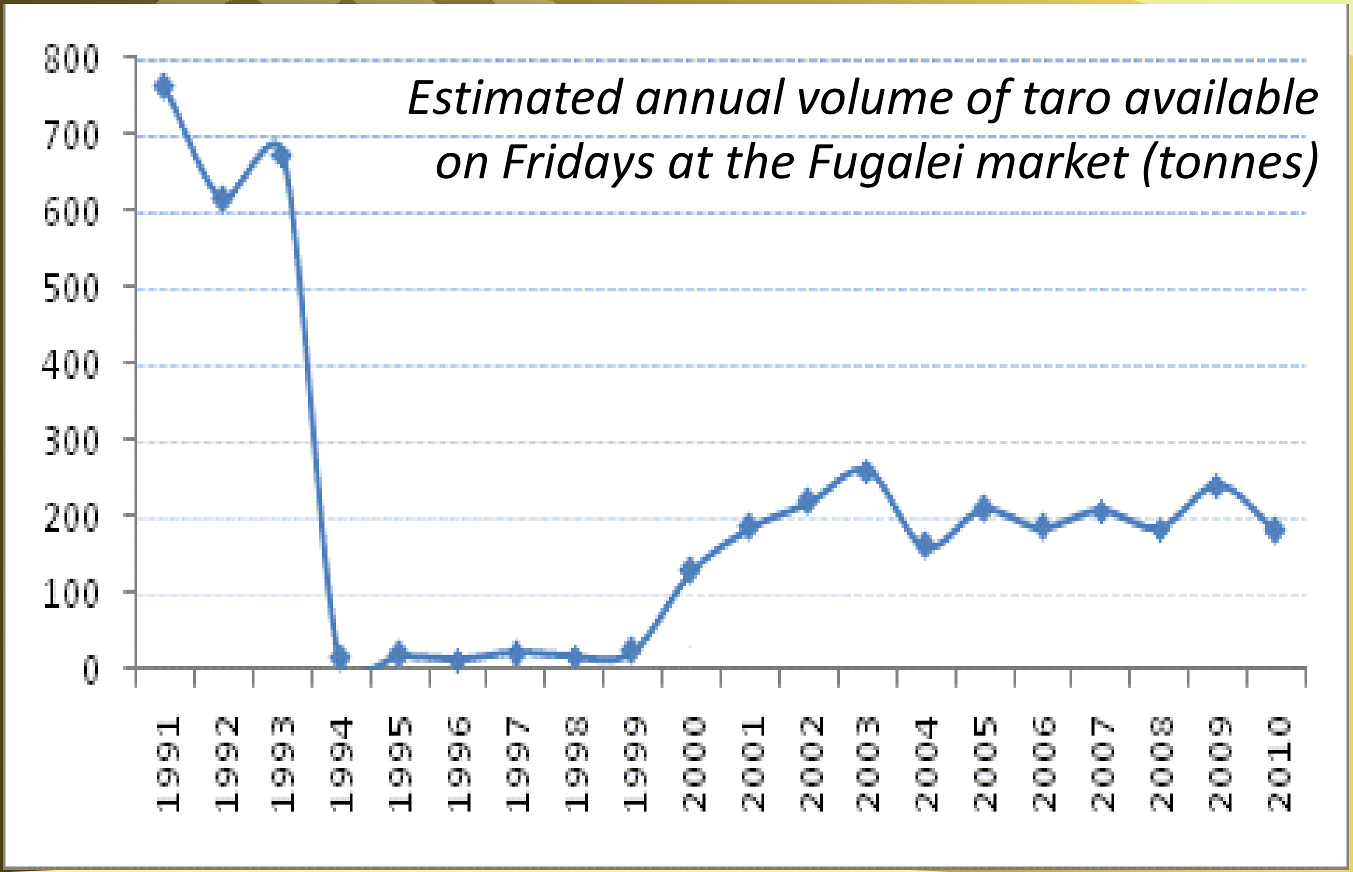
Samoan total consumption of taro, wheat and rice - 1987 to 2007 (1,000 tonnes)



Samoan per capita consumption of taro, wheat and rice, 1987 to 2007 (kg/pers/year)



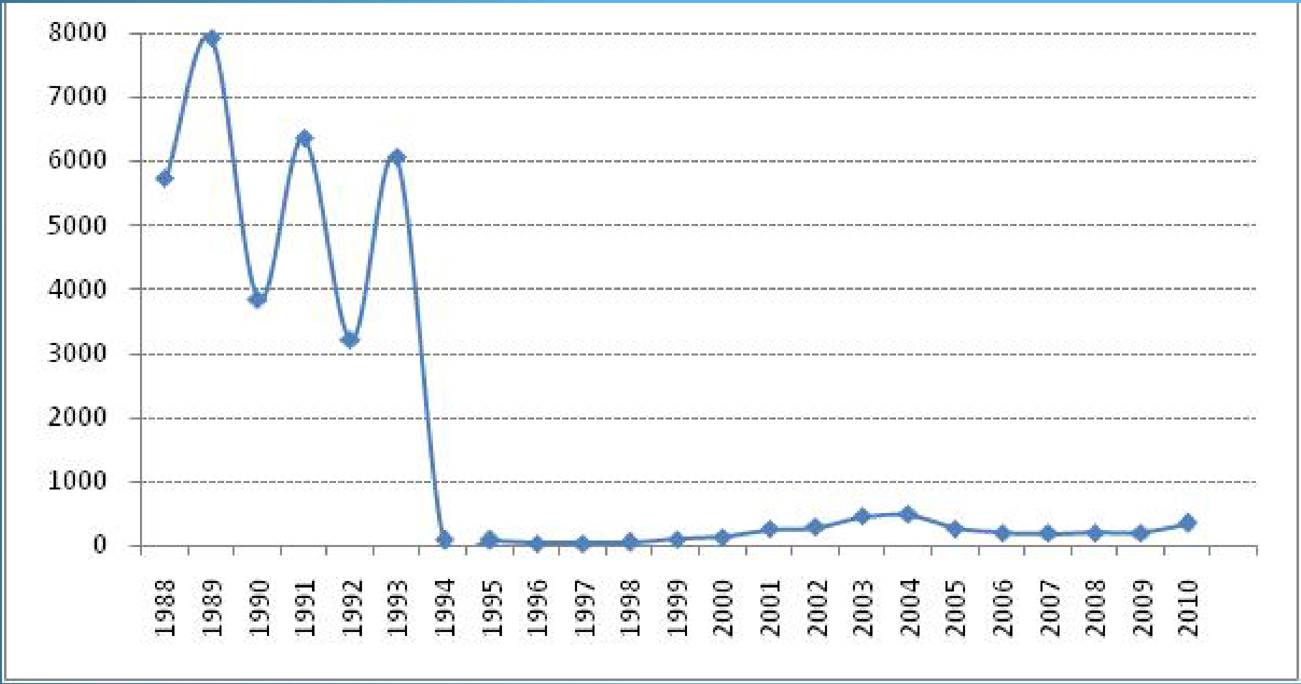
Impact of TLB on taro production can also be gleaned from availability of taro at Fugalei market, Apia



Impact on taro exports

TLB meant that Samoa not only lost its main food crop, but also its main export earner

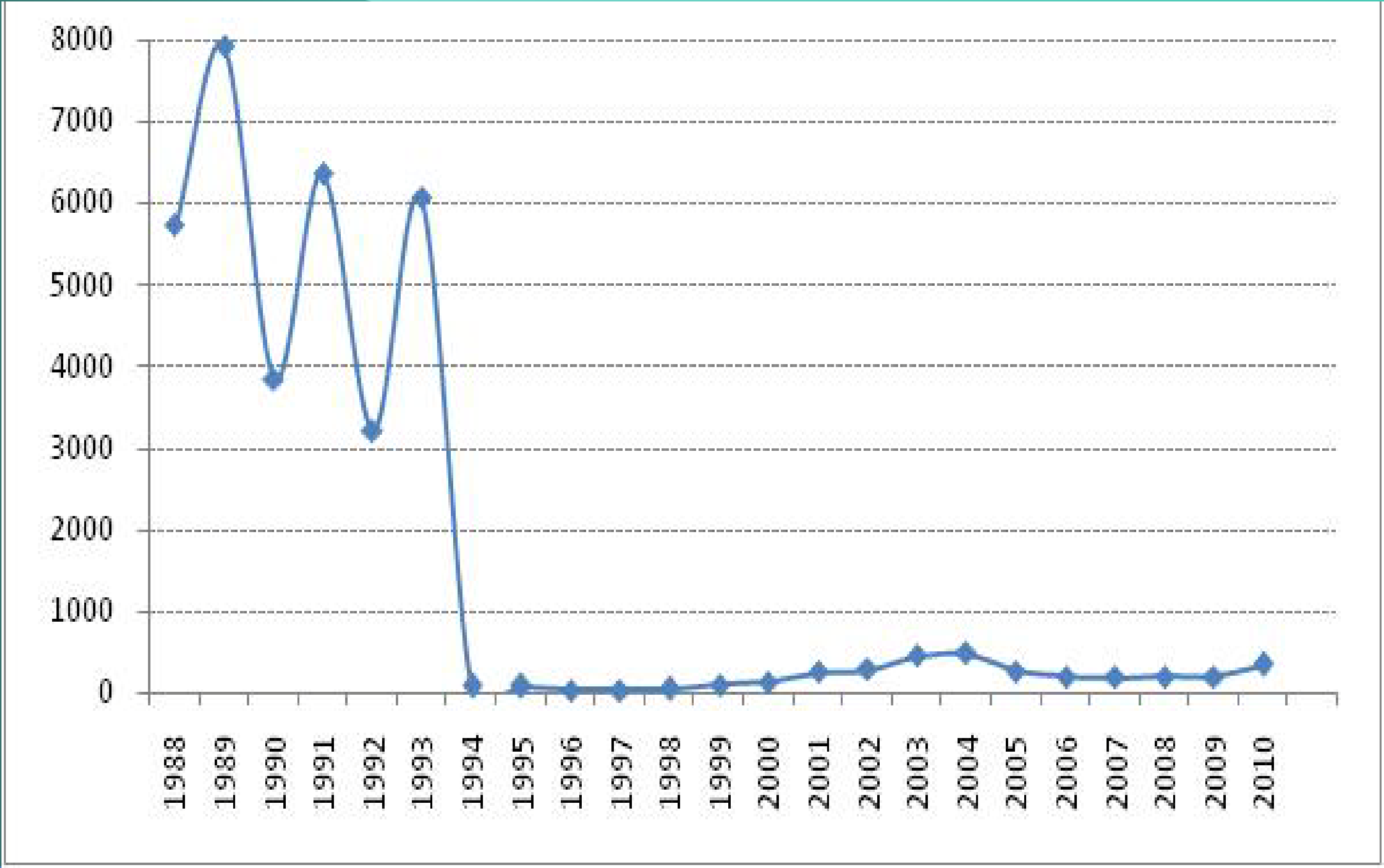
Samoan taro exports (tonnes) – Central Bank of Samoa Statistics



Impact on taro exports

Value of Samoa's taro exports ('000 tala)

– Central Bank of Samoa Statistics



The public policy and investment response to TLB

- Short-term adaptation response with existing taro varieties - **this failed**
- Medium term response through introducing TLB tolerant and resistant varieties **-partially successful**
- Long term response through breeding TLB tolerant and resistant varieties **-highly successful**

Narrow gene pool of Pacific islands taro - the need to introduce exotic varieties

- Introducing TLB resistant varieties from Micronesia and South East Asia - this had some initial success as a ‘stop gap’ measure
- A breeding programme to broaden the taro gene pool: complementary regional and national programme

The taro breeding program

- ***The challenge***: find resistant varieties, but also meet demanding **taste requirements of Samoan communities** at home and abroad, and provide for a **shelf life** that would allow export by sea
- challenge met by using a classical plant breeding approach which incorporated a high level of **grower participation**

- Initially, breeding programme involved USP plant breeders - later external funds incrementally obtained from AusAID (TAROGEN project and support for regional germplasm conservation at the Centre for Pacific Crops and Trees (CePaCT))

- TLB resistant crop breeding activities were developed **incrementally** over time

Quantifying the benefits and costs of the Samoan taro germplasm development programme

- Measuring benefits to date
- Projecting benefits into the future

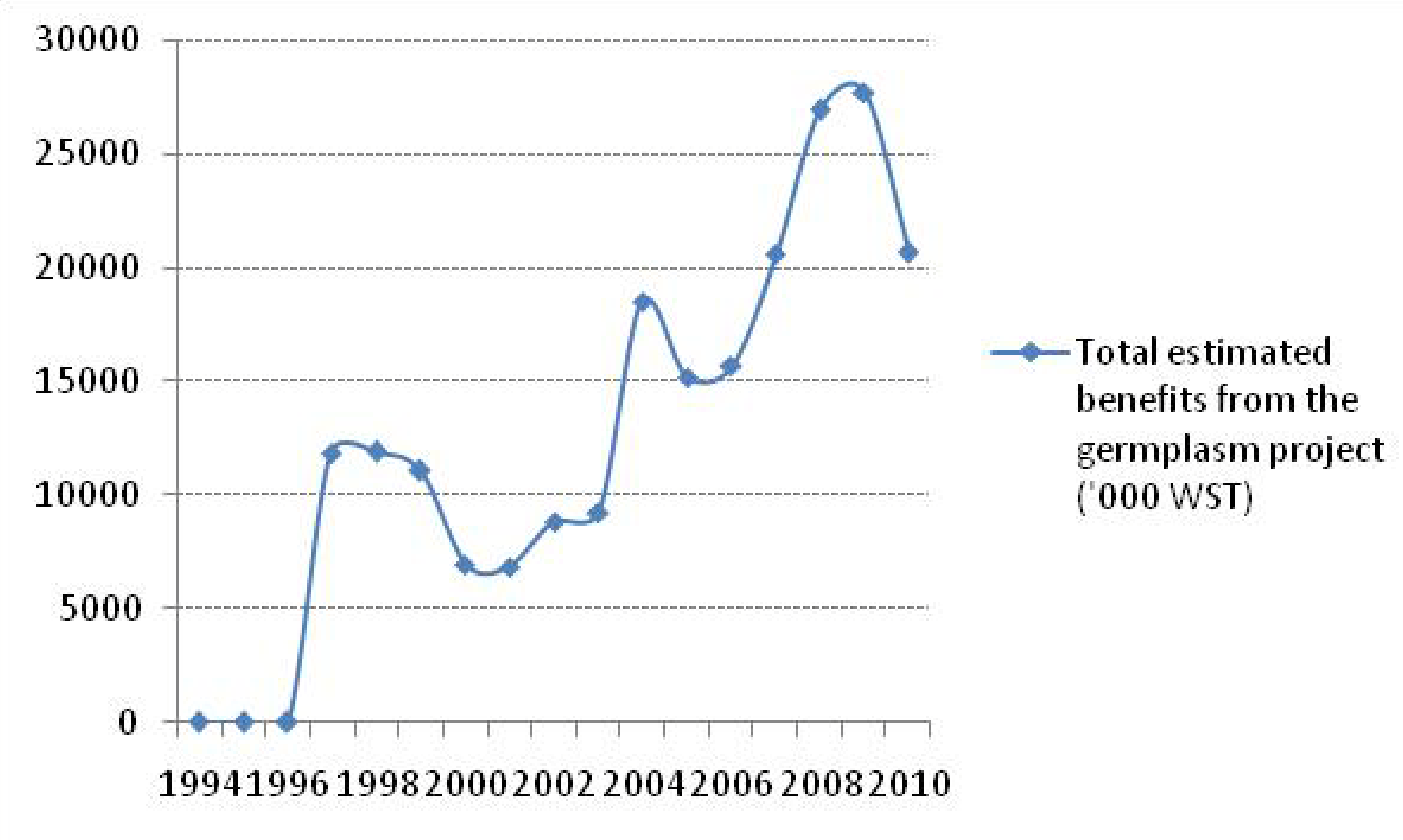
Measuring the realised benefits

Valuing taro consumption

- Today, Samoa would be producing virtually **no taro** had there not been **public investment** in the taro germplasm development programme
- Fugalei Market Surveys indicate around 500 tonnes of taro now sold annually - total consumption of all types (*Colocasia, Xanthosoma* and *Alocasia)* is now in the order of **18,000 tonnes** - Estimated now to be half *Colocasia*
- Subsistence taro is valued at Fugalei market price – measure of what consumers would pay for taro if it was purchased

Estimated realised benefits from taro germplasm development programme

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Estimated taro consumption (all types) (tonnes)	5,000	5,000	7,000	14,000	14,000	15,000	15,000	15,000	15,500	16,000	16,000	16,000	16,000	16,500	17,000	17,000	17,500
percent colocasia	0.05	0.04	0.04	0.15	0.15	0.15	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.50	0.50	0.50
Estimated colocasia consumption (tonnes)	250	200	280	2,100	2,100	2,250	2,250	3,000	3,875	4,800	5,600	6,400	7,200	8,250	8,500	8,500	8,750
estimated consumption resulting from the germplasm program (tonnes)	-	-	-	1,900	1,900	2,050	2,050	2,800	3,675	4,600	5,400	6,200	7,000	8,050	8,300	8,300	8,550
Fugalei market price ('000 WST/tonne				6.24	6.27	5.19	3.04	2.16	2.13	1.73	3.06	2.32	2.16	2.48	3.14	3.24	2.30
Imputed value of taro consumption resulting from the germplasm program ('000 WST)	-	-	-	11,856	11,913	10,644	6,224	6,037	7,842	7,944	16,543	14,356	15,092	19,998	26,066	26,873	19,688
Value of taro exports resuling from the germplasam program ('000 WST)	-	-	-	-	-	432	716	814	1,005	1,314	1,975	846	595	622	858	874	1,109
Total estimated benefits from the germplasm project	**-**	**-**	**-**	**11,856**	**11,913**	**11,076**	**6,940**	**6,851**	**8,847**	**9,258**	**18,518**	**15,202**	**15,687**	**20,620**	**26,924**	**27,747**	**20,797**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Total estimated benefits from the germplasm project ('000 WST)

Estimated future economic benefits from the taro germplasm development programme

Benefits *will continue to be realised* ***into the future***

- Domestic consumption
- Exports

Domestic consumption projections

- Domestic taro consumption still remains below half what it was prior to TLB - continued growth in domestic taro consumption can be expected, albeit at declining rate
  - Unlikely to return to pre TLB consumption levels - fundamental changes in Samoan consumption patterns towards imported grains
  - Estimated that over the next decade the domestic consumption of taro will increase to around 10,000 tonnes

Taro export projections

- Greater growth can be expected in export of taro, (rather than in domestic consumption) over the next decade - with **greater acceptance of the new varieties** by the **Samoan community living in New Zealand** and **further development of new varieties** that meet taste requirements of Samoans living overseas

- 10% annual growth in volume of taro exports is projected

Some offsetting benefit losses to other PICs

- Fiji will lose market share
- Not a zero sum game
- Samoan taro development programme has provided insurance for Fiji taro against the future eventuality of TLB

Regional and international benefits

- Other countries can now respond to the threat of TLB
  - reactively
  - better still, **proactively!**

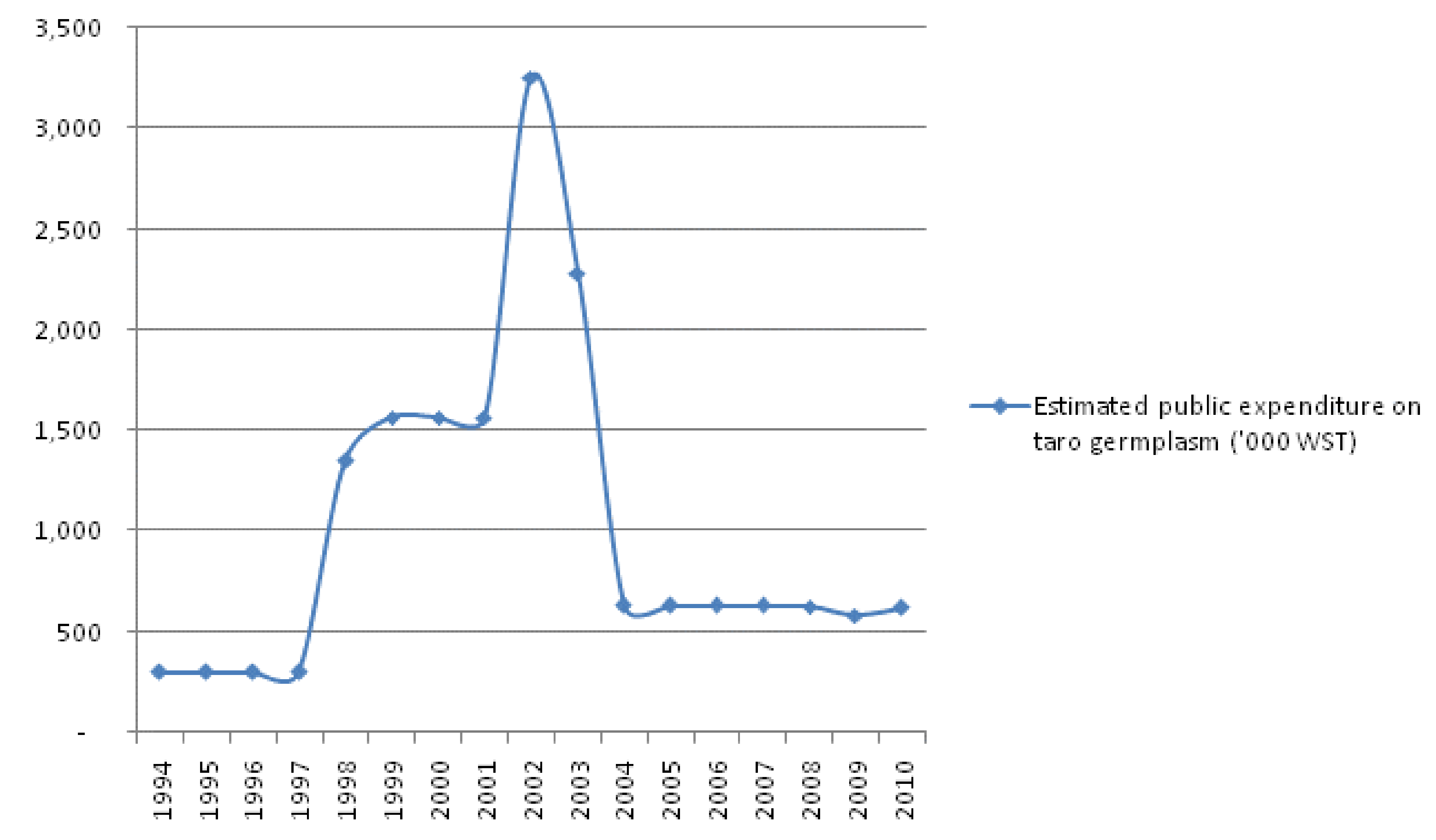
The actual cost of the taro germplasm development programme

From 1994 -2010, WST 18 million (AUD 8 million) spent on taro germplasm development and distribution. Involved numerous partners:

- **AusAID** funding of TaroGen
- **ACIAR funding** of UQ (DNA fingerprinting and virus testing)
- **New Zealand Ministry of Foreign Affairs and Trade** funding of HortResearch to develop methods to assess TLB resistance
- **SPC -** share of the running of the genebank at CePaCT and funding after TaroGen
- **USP** funding prior to TaroGen and funding after TaroGen
- **Samoa Ministry of Agriculture** cost of testing and distribution of taro germplasm

Expenditure on Samoan taro germplasm development and distribution (WST '000)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
AusAID funding of TaroGen					1,020	1,020	1,020	1,020	1,020									**5,100**
ACIAR DNA/virus testing									1,760	1,760								**3,520**
NZ Aid						70	70	70										**210**
SPC genebank						143	143	143	143	143	143	143	143	143	143	143	143	**1,716**
SPC					20	20	20	20	20	20	78	78	78	78	72	28	28	**560**
USP	50	50	50	50	10	10	10	10	10	60	60	60	60	60	60	60	100	**770**
Samoa Dept Ag	250	250	250	250	300	300	300	300	300	300	350	350	350	350	350	350	350	**5,250**
Total	300	300	300	300	1,350	1,563	1,563	1,563	3,253	2,283	631	631	631	631	625	581	621	**17,126**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Estimated public expenditure on taro germplasm ('000 WST)

Comparing the realised benefits to actual costs

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Program benefits('000 WST)						11,856	11,913	11,076	6,940	6,851	8,847	9,258	18,518	15,202	15,687	20,620	26,924	21,503	185,195
Program costs ('000 WST)	300	300	300	300	1350	1563	1563	1563	3253	2283	631	631	631	631	625	581	621	500	17,626
Benfits - Costs	(300)	(300)	(300)	(300)	(1,350)	10,293	10,350	9,513	3,687	4,568	8,216	8,627	17,887	14,571	15,062	20,039	26,303	21,003	167,569

	r(i) = 0	r(i)= 2%	r(i) = 5%	r(i)=10%	r(i)=15%
NPV Benefits	185,195	157,873	126,338	90,852	68,491
NPV Costs	17,626	14,695	11,374	7,722	5,473
B/C	10.5	10.7	11.1	11.8	12.5

Analysing results

•Over the period 1994-2011, **quantifiable benefits** have been more than **10 times the cost of programme**

•NPVs calculated for benefits and costs for a range of discount rates:

-For discount rate of 2%(appropriate social rate of discount for a long, broad-based development project), benefit cost ratio is 10.7. When discount rate increased to 15%(rate more appropriate for private investment project with a relatively short time horizon) there is a small increase in the benefit cost ratio

- **Apparent anomaly?** Can be explained by *unusual flow* of programme benefits and costs through time from the two successive germplasm programme parts

Extrapolating benefits and costs into the future

Projected benefits

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
tonnes consumed	8,969	9,193	9,423	9,658	9,900	10,147	10,401	10,661	10,928	11,201
value ('000 WST)	20,628	21,144	21,672	22,214	22,770	23,339	23,922	24,520	25,133	25,762
tonnes exported	350	385	424	466	512	564	620	682	750	825
value ('000 WST)	875	963	1,059	1,165	1,281	1,409	1,550	1,705	1,876	2,063
Total value of taro production ('000 WST)	**21,503**	**22,106**	**22,731**	**23,379**	**24,051**	**24,748**	**25,472**	**26,225**	**27,009**	**27,825**

Ongoing costs in realising future benefits

- Extension programme continues
- Work on gaining greater consumer acceptability in export markets
- Breeding program begins to focus on drought resistance

Note: an annual expenditure of WST 800,000 (in 2011 prices) is provided for in projections

Incorporating future benefits and costs into the BCA

[redacted]

	r(i) = 0	r(i)= 2%	r(i) = 5%	r(i)=10%	r(i)=15%
NPV Benefits	408,195	313,659	218,923	131,487	87,236
NPV Costs	24,826	19,267	13,737	8,551	5,782
B/C	16.4	16.3	15.9	15.4	15.1

Analysing results

- Taking into account future benefits and costs, there is a substantial increase in the B/C ratio.
- Expected inverse relationship between B/C ratio and the discount rate is restored as future benefits and costs are taken into account and offset early against low cost benefits of the initial exotic introductions
- Confirms exceptionally high economic return from public investment in the taro germplasm programme

Vanuatu case study: Evaluation of a proactive response to climate change

Vanuatu does not yet have TLB and other major root crop diseases

- Approach relies on evaluating **local diversity, incorporating some exotic diversity** and then **distributing large volumes of planting material** for farmers to select from, and then conserve

- By **enriching** farmers' varietal portfolios **protection is provided** against future epidemics and biological disasters

- Pilot project (involving 10 villages) implemented by VARTC (with support from CIRAD) in collaboration with the Farm Support Association

Evaluation of pilot project

- Pilot project confirmed **interest** of ni-Vanuatu village farmers in obtaining new root crop varieties and their **ability to manage** these new varieties and to expand diversity
- **Significant impact** can be achieved **despite logistical challenges** involved with distribution of perishable planting material in rural Melanesia

Evaluation of pilot project

- **Significant up-front costs** involved in establishing and screening germplasm material for distribution to farming communities
- Once collection is with farm community (**in-situ**), **no additional government or donor resources are required** for sustainability
- Pilot project justified in own right -however, significant benefit as a climate change adaptation strategy can only be realised if there is a **substantial scaling up**

BCA of a scaled-up project to **expand Vanuatu's root crop gene pool** to provide protection against biological disasters and epidemics brought about by climate change

Proposed project and its costs

- 4-year project implemented by VARTC and FSA is proposed
- total cost estimated at approximately VUV 67 million (AUD 520,000)

	Vatu
Personnel	19,000,000
Travel and transportation costs	24,000,000
Planting material costs	9,800,000
Training costs	2,060,000
Communication costs	3,320,000
Total cost	58,180,000
FSA overheads	8,727,000
Grand Total	66,907,000

Estimating future benefits

- Proposed project is a **proactive** ‘no regrets’ response, impending biological disaster
- Readily quantifiable means of measuring economic impact of loss of a basic food staple is ***vatu* value of the resulting increase in grain imports**
- **Does not measure full impact** - other costs associated with nutrition, loss of income and multiplier impacts on the economy

Measuring Vatu value of increased grain imports resulting from a biological disaster

- 20 % of Vanuatu's food energy needs supplied by imported food - grain accounts for more than half of this amount

- **Samoan experience** shows large impact a biological disaster such as TLB can have on grain imports

Simulating impact of a future root crop biological disaster on the value of grain imports

[redacted]

...**Higher + even more volatile** world grain prices can be expected in future

B/C ratios for different impact scenarios 'without' the project

- **5% increase** in grain imports from **year 5** onwards
- **5% increase** in grain imports from **year 2** onwards
- **20% increase** in grain imports from **year 5** onwards
- **20% increase** in grain imports from **year 2** onwards

Case 1: 5% increase in grain import from year 5 onwards

Year	1	2	3	4	5	6	7	8	9	10	Total
Benefits (million vatu)	0	0	0	0	67	67	67	67	67	67	402
Cost (million vatu)	17	17	17	17	0	0	0	0	0	0	68
B-C	-17	-17	-17	-17	67	67	67	67	67	67	

	r(i) = 0	**r(i)= 2%**	**r(i) = 5%**	**r(i)=10%**	**r(i)=15%**
NPV Benefits	**402**	**282**	**280**	**212**	**199**
NPV Costs	**68**	**65**	**60**	**58**	**47**
B/C	**5.9**	**4.4**	**4.6**	**3.6**	**4.2**

Case 2: 5% increase in grain import from year 2 onwards

Year	1	2	3	4	5	6	7	8	9	10	Total
Benefits (million vatu)	0	67	67	67	67	67	67	67	67	67	603
Cost (million vatu)	17	17	17	17	0	0	0	0	0	0	68
B-C	-17	50	50	50	67	67	67	67	67	67	

	r(i) = 0	**r(i)= 2%**	**r(i) = 5%**	**r(i)=10%**	**r(i)=15%**
NPV Benefits	**603**	**471**	**454**	**328**	**351**
NPV Costs	**68**	**65**	**60**	**58**	**47**
B/C	**8.9**	**7.3**	**7.5**	**5.6**	**7.4**

Case 3: 20% increase in grain import from year 5 onwards

Year	1	2	3	4	5	6	7	8	9	10	Total
Benefits (million vatu)	0	0	0	0	269	269	269	269	269	269	1614
Cost (million vatu)	17	17	17	17	0	0	0	0	0	0	68
B-C	-17	-17	-17	-17	269	269	269	269	269	269	

	r(i) = 0	**r(i)= 2%**	**r(i) = 5%**	**r(i)=10%**	**r(i)=15%**
NPV Benefits	**1,614**	**1,327**	**1,123**	**939**	**800**
NPV Costs	**68**	**65**	**60**	**58**	**47**
B/C	**23.7**	**20.5**	**18.6**	**16.1**	**17.0**