EXAMPLE 1: HYPOTHETICAL CASE OF AN EX-POST ECONOMIC IMPACT STUDY

1. The first step in impact assessment is to obtain estimates of the total quantity produced (Q, in metric tons) and the producer price (P, in FCFA per ton), for each year since this hypothetical new technology was introduced.   It is also necessary to obtain a consumer price index in order to convert that price into real terms, by dividing the nominal price by the index. Note that the price index must use 1 as a base.

MARKET DATA ON NOMINAL AND REAL PRICES

Year	Quantity Produced (t) [Q]	Nominal Price (CFA/t)	Consumer Price Index (1993=1)	Real Price (93CFA/t) [P]
1984	29000	33550	0.62	54113
1985	33000	34050	0.63	54048
1986	30000	33250	0.65	51154
1987	38000	37900	0.69	54928
1988	41000	39800	0.71	56056
1989	45000	39900	0.75	53200
1990	47000	41100	0.79	52025
1991	49000	45900	0.85	54000
1992	51000	47900	0.93	51505
1993	50000	49500	1.00	49500

2. The second step is to obtain agronomic data on yields with and without the new technology. In this case, yields with the new technology (Yn) are only known for the period from 1984 to 1986 (years of on-farm trials before diffusion). For simplicity, from 1987 to 1993 we will assume that the mean yield increase obtained during the trials is maintained (dY=0.04). The increase in yield is the difference between the yield with (Yn) and without (Yt) the new technology.

AGRONOMIC DATA ON YIELDS WITH NEW AND OLD TECHNOLOGY

	Yield: New Technol. (t/ha) [Yn]	Tradi- tional Technol. (t/ha) [Yt]	Yield Increase (t/ha) [dY]
1984	0.32	0.290	0.03
1985	0.34	0.300	0.04
1986	0.30	0.250	0.05
1987			0.04
1988			0.04
1989			0.04
1990			0.04
1991			0.04
1992			0.04
1993			0.04

3. Next, the adoption rate (t) must be calculated, in terms of the acreage under the new technolog divided by the total acreage under cultivation. Adoption data may be obtained from farm surveys, extension workers, or estimated from sales of seeds and other inputs. To use the adoption rate ir calculating each year's proportional increase in production (j), we will need to divide it by the he national mean yield (Ym), obtained by dividing total production (Q) by the total acreage (A) under cultivation. With those parameters, the proportional increase in production can be computed following the formula: j=dY*t/Ym.

AGRONOMIC DATA ON ADOPTION AND PRODUCTION INCREASES

	AREA PLANTED:		Adoption	Mean	
	Total	With the	Rate	National	Proportional
	in prod-	New	(Prop.of	Yield	Production
	uction	Technol.	area)	(t/ha)	Increase
	(ha)	(ha)	[t]	[Ym]	[j=dY*t/Ym]
1984	100000	0	0.00	0.290	0.000
1985	110000	0	0.00	0.300	0.000
1986	120000	0	0.00	0.250	0.000
1987	140000	5600	0.04	0.271	0.006
1988	150000	12000	0.08	0.273	0.012
1989	140000	16800	0.12	0.321	0.015
1990	150000	24000	0.16	0.313	0.020
1991	170000	34000	0.20	0.288	0.028
1992	190000	47500	0.25	0.268	0.037
1993	190000	47500	0.25	0.263	0.038

5. Next, we must calculate adoption costs, starting with the level of costs per hectare. To turn costs per hectare into costs per tonne, they must be divided by the average yield (Ym). Adoption costs enable us to compute the proportional increase in costs [c=(dC*T)/(Ym*P)].

	ADOPTION COSTS		Proportional
	Nominal	Real	Increase
	(CFA/ha)	(93CFA/ha)	in Costs
		[dC]	[c= (dC*T)/(Ym*P)]
1984	740	1194	0.000
1985	750	1190	0.000
1986	800	1231	0.000
1987	820	1188	0.003
1988	850	1197	0.006
1989	900	1200	0.008
1990	950	1203	0.012
1991	1020	1200	0.015
1992	1100	1183	0.021
1993	1200	1200	0.023

6. The next step is to compute the k parameter, or net shift in the supply curve. This requires an estimate of the supply elasticity (E). Here we use 0.8, a value that would be typical for a food cro with some potential for area expansion. Then, the k parameter is computed by dividing j by E and by subtracting c from the result.   To obtain social gains, the elasticity of demand (e) is also needed, and here we use 0.4, a value that would be typical for a food product which has few available substitutes and is not traded internationally. The increase in production (dQ) is obtaine with these data in the formula dQ=(Q*e*E*k)/(E+e), and social gains are computed with the following formula SG=(k*P*Q)-(.5*k*P*dQ).

ECONOMIC PARAMETERS AND THE SOCIAL GAINS FROM RESEARCH

	ELASTICITIES		"k" Param. [k = (j/E)-c]	Quantity Increase [dQ= QeEk/ (E+e)]	Social Gains [SG= kPQ- .5kPdQ]
	Supply [E]	Demand [e]		(mt)	(millions CFA)
1984	0.8	0.4	0.000	0	0.00
1985	0.8	0.4	0.000	0	0.00
1986	0.8	0.4	0.000	0	0.00
1987	0.8	0.4	0.004	42	8.72
1988	0.8	0.4	0.008	92	19.25
1989	0.8	0.4	0.010	123	24.49
1990	0.8	0.4	0.014	172	33.51
1991	0.8	0.4	0.019	252	50.87
1992	0.8	0.4	0.025	342	65.92
1993	0.8	0.4	0.024	326	60.36

7. Finally, it is necessary to incorporate the costs of research and extension, in real terms (adjusted for inflation), to obtain social benefits for each year. This is done by dividing nominal expenditures by the price index. The net social benefits, in real terms, is computed by subtracting program costs from the gross social gains obtained in step 6.

To calculate the internal rate of return (IRR) is computed by using a formula, for example @IRR i the English version of Lotus, using the net social gain data from 1984 to 1993. The net present value is computed by using @NPV in the English version of Lotus.

RESEARCH AND EXTENSION COSTS AND SOCIAL GAINS

	Research	Extension	Total	Real Costs	Net Social Gains
	(millions on FCFA)			(1993CFA)	(1993CFA)
1984	5.0		5.0	8.06	-8.06
1985	5.0		5.0	7.94	-7.94
1986	6.0	9.0	15.0	23.08	-23.08
1987	6.0	11.0	17.0	24.64	-15.92
1988	0.0	15.0	15.0	21.13	-1.88
1989	0.0	15.0	15.0	20.00	4.49
1990	0.0	16.0	16.0	20.25	13.26
1991	0.0	17.0	17.0	20.00	30.87
1992	0.0	20.0	20.0	21.51	44.42
1993	0.0	20.0	20.0	20.00	40.36

Internal Rate of Return:	16%
Net Present Value (NPV) at 10%:	14.87

EXAMPLE 2. AN ACTUAL STUDY OF SORGHUM RESEARCH IN CAMEROON

This second example, drawn from an actual case study, enables us to calculate the impact of a new variety of sorghum (S35) introduced in Cameroon. There are two major differences from the hypothetical example described in example 1.

(1) the domestic prices are observed only from 1984 to 1989. Prices for
   1990 to 1992 are estimated on the basis of the opportunity cost of importing maize.
(2) the results of "on-farm" trials are available only for years from 1984 to 1989.
   It is assumed that the PROPORTIONAL increase remains constant, at the 1984
   level (85%) fro all the dry years (for example, 1991) and at the mean level for
   1985-1987 (7%) for all the other years.

The calculations and the data transformation leading to the net social gain and the internal rate of return calculations are described in the following steps:

1. Domestic prices for sorghum are observed for the period 1984 to 1989, and are estimated from 1990-1992 on the basis of the opportunity cost. The formula used is the following: export price of maize (FOB-USA) x 0.9 + US$40/t freight + 20% marketing costs, to get an estimated CIF value for sorghum in US$ per ton.

The opportunity cost is obtained by mutiplying the CIF price equivalent for sorghum by the exchange rate (to obtain FCFA), and by dividing the result by 1000 to convert the price to FCFA per kg.

MARKET DATA ON PRODUCTION AND PRICES

	Acreage (000 ha)	Prod. (000 t)	Mean Yield (kg/ha)	Domestic Price (CFA/kg)	Opport. Costs (CFA/kg)	Maize FOB US Gulf (US$/t)	Sorghum CIF Equival. (US$/t)	Exchange Rate (CFA/US$)
1984	374.5	203.2	543	113.9	116.3	202	222	437
1985	447.7	338.5	756	78.5	101.6	165	189	449
1986	511.9	541.5	1058	38.9	57.7	110	139	346
1987	346.8	236.3	681	64.0	42.4	86	117	301
1988	517.8	418.2	808	47.2	50.7	113	142	298
1989	515.9	343.2	665	43.0	56.3	119	147	319
1990	500.0	350.0	700	49.7	49.7	109	138	300
1991	500.0	230.0	460	41.8	41.8	99	129	270
1992	500.0	350.0	700	42.1	42.1	100	130	270

2. The next step is to incorporate agronomic data. In this case, the new technology involves only a change of variety, with negligible additional costs compared to other varieties, so adoption costs are ignored.   We need only data on yields and adoption. For relative yields, actual observations are available only from 1984 to 1987. To look beyond those years we must make some assumption about the performance of S35 relative to existing varieties. For simplicity, we assume that the PROPORTIONAL yield increase remains constant, at the 1984 level (85%) for all the dry years (for example 1991) and at the mean level for 1985-1987 (7%) for all the other years. The proportional increase is obtained by computing the difference between the S35 and the traditional yields (dY) and by dividing the difference by the traditional yield. It is not possible to use the mean yield (Ym) because the trial results show average yields which are larger than Ym indicating that the trials were conducted in privileged areas.

3. Data on adoption are derived from extension workers' estimates. The poportional adoption rate (t) is computed by dividing the acreage planted to S35 by the total acreage. The proportional increase in production (j) is computed using the following formula $j = t \cdot dY/Ym$

AGRONOMIC DATA ON YIELDS AND ADOPTION RATES

	Observed yields (from on-farm trials)		Propor-tional		Adoption of S35		Proportional Increase in
	S35 (kg/ha)	Trad. (kg/ha)	Increase (dY/Ym)	Rainfall Conditions	------------ (000 ha)	------------- (t)	Production [j=t*dY/Ym]
1984	1333	719	0.85	Dry			0
1985	1689	1539	0.10	Norm.			0
1986	1866	1721	0.08	Good	0.65	0.001	0.000
1987	1888	1825	0.03	Norm.	5	0.014	0.000
1988			0.07	Norm.	12	0.023	0.002
1989			0.07	Norm.	18	0.035	0.003
1990			0.07	Norm.	26	0.052	0.004
1991			0.85	Dry	28	0.056	0.048
1992			0.07	Norm.	30	0.060	0.004

4. To compute social gains we need economic parameters (supply and demand elasticities). Here we use estimates which are typical for a major food crop which has some potential for area expansion (elasticity of supply=0.8), and faces limited potential for increased demand (demand elasticity=0.3). (Here we assume that it doesn't enter international trade). The k parameter is computed by dividing j by E and by subtracting c from the result (k=j/E - c). The increase in production (dQ) is computed using the following formula: dQ=(Q*e*E*k) / (E+e). The gross social gains are computed by applying the formula for a rectangle plus a triangle: SG = (k*P*Q) - (0.5*P*dQ).

	ELASTICITIES		SOCIAL GAINS COMPUTATION		
	------------	--------------			
	Supply	Demand	"k" Param.	Increase in Qty. ('000 mt)	Social Gains (CFA millions)
1986	0.8	0.4	0.0001	0.01	3.1
1987	0.8	0.4	0.0006	0.06	16.5
1988	0.8	0.4	0.0021	0.30	44.0
1989	0.8	0.4	0.0031	0.20	47.6
1990	0.8	0.4	0.0047	0.52	92.5
1991	0.8	0.4	0.0598	5.47	889.2
1992	0.8	0.4	0.0054	0.50	94.1

5. Finally, it is necessary to subtract program research and extension costs, which were calculate
on the basis of data from a document by J.A. Sterns and R.H. Bernsten, entitled "Assessing the
Impact of Cowpea and Sorghum Research and Extension: Lessons Learned in Northern
Cameroon." (Agricultural Economics Department, Michigan State University, 1992). The net socia
gain is obtained by subtracting the program costs from the gross social gains obtained in step 4.
With these data, the Internal Rate of Return (IRR) is computed using the @IRR formula
in the English version of Lotus or a similar command in other spreadsheet software.

	PROGRAM COSTS			SOCIAL GAINS		
	Total Cost (US$)	Exchange Rate (CFA/US$)	Total Costs ...(CFA millions)...	Gross	Net	Internal Rate of Return (IRR):
1979	50423	213	10.7		-11	2.3%
1980	48005	211	10.1		-10	
1981	262977	272	71.5		-72	
1982	447181	329	147.1		-147	
1983	397776	381	151.6		-152	
1984	462880	437	202.3		-202	
1985	529689	449	237.8		-238	
1986	532495	346	184.2	3.1	-181	
1987				16.5	17	
1988				44.0	44	
1989				47.6	48	
1990				92.5	93	
1991				889.2	889	
1992				94.1	94	

The IRR is noticeably low: this is due to the relatively long research period: 8 years before the firs
year of gain, and 13 years before the first large gain (in 1991). However, it is important to note th
we have considered that actual gains obtained obtained by the producers. The "insurance" value
S35 was not taken into account in this study.

EXAMPLE 3. THE CASE OF COTTON IN SENEGAL

The example of cotton research in Senegal developed in the text is repeated in this exercise. This example enables us to calculate the economic impact of the introduction of several new varieties at once. This complicates the calculations of the adoption rate and of the increase in yield (dY) since the cumulative increase must be considered.

All of the data for this study are included in a spreadsheet file entitled "example3.wk1". Correct formulas to compute the parameters j,c,k, dQ, social gain and the internal rate of return appear in the file entitled "complet3.wk1". The calculations and data transformation are described in the following steps:

MARKET DATA ON QUANTITIES AND PRICES

	Acreage (ha) [At]	Produc- tion (t) [Q]	Mean Yield (kg/ha) [Ym]	Nominal Fiber Price (CFA/kg)	Consumer Price Index (1993=1)
1971	13,618	11,832	869		
76	39,206	30,685	783		0.426
77	43,845	45,208	1,031		0.475
78	47,109	37,166	789		0.491
79	48,299	33,806	700	49.0	0.538
80	30,908	26,868	869	53.5	0.585
81	29,913	20,607	689	58.8	0.620
82	31,977	41,007	1,282	67.8	0.728
83	42,018	47,081	1,120	70.1	0.812
84	33,353	30,461	913	69.9	0.908
85	46,337	46,913	1,012	69.4	1.027
86	38,848	27,942	719	99.6	1.089
87	25,482	26,871	1,055	99.8	1.044
88	28,878	38,816	1,344	99.7	1.025
89	38,558	38,703	1,004	99.7	1.030
90	24,183	29,303	1,212	99.8	1.033
91	43,341	44,723	1,032	99.9	1.015
92	44,164	50,577	1,145	100.0	1.015
93	44,772	47,536	1,072	99.2	1.000

Impacts of Research using Economic Surplus Spreadsheets

1. The data on acreage under the new technologies enable us to calculate the
adoption rate beginning in 1985, the starting date for diffusion. Considering that several
varieties were introduced from 1985 to 1993, the adoption rate (t) is computed by
dividing the acreage for each variety by the total acreage planted in the new variety.

AGRONOMIC DATA ON ADOPTION
Acreage under the new technology (ha)

	BJA	L 299	Irma 9697	Irma 1243	Stam F	Stam 42	Total
80	30532	376					30908
81	29781	118					29899
82	29376	2400					31776
83	16246	25772					42018
84	10300	23058					33357
85		46337	13				46350
86		38594	255				38849
87		20121	5362				25483
88		44	28834				28878
89			36735	1855			38590
90			8766	15417			24183
91				35526			35526
92				44075	89		44164
93				43661	1106	5	44772
94				28450	14189	106	42745

Adoption rate for the new technologies (t)

	BJA	L 299	Irma 9697	Irma 1243	Stam F	Stam 42	Total
80	0.99	0.01					1.00
81	1.00	0.00					1.00
82	0.92	0.08					1.00
83	0.39	0.61					1.00
84	0.31	0.69					1.00
85		1.00	0.00				1.00
86		0.99	0.01				1.00
87		0.79	0.21				1.00
88		0.00	1.00				1.00
89			0.95	0.05			1.00
90			0.36	0.64			1.00
91				1.00			1.00
92				1.00	0.00		1.00
93				0.98	0.02	0.00	1.00
94				0.67	0.33	0.00	1.00

Appendix - Computer Exercises

2. The increase in cumulative yield (dY) is computed on the basis of experimental data comparing the yields for a new variety with those of the preceeding variety. The yield increase is cumulative from one variety to another, with respect to the BJA.

AGRONOMIC DATA (CONTINUED)

Cumulative yield gains (kg/ha) [dY]

	L 299	Irma 9697	Irma 1243	Stam F	Stam 42
80	78				
81	78				
82	78				
83	78				
84	78				
85	78				
86	78	272			
87	78	272			
88	78	272			
89		272			
90		272	270		
91			270		
92			270	332	
93			270	332	356
94			270	332	356

3. The proportional increase in production (j) is computed by applying the following formula: j= dY*t/Ym, where Ym is the mean yield.

Proportional increase in production [j]

	L 299	Irma 9697	Irma 1243	Stam F	Stam 42	Total
80	0.001					0.0011
81	0.000					0.0004
82	0.005					0.0046
83	0.043					0.0427
84	0.059					0.0591
85	0.077					0.0771
86	0.108	0.002				0.1103
87	0.058	0.054				0.1126
88	0.000	0.202				0.2022
89		0.258				0.2579
90		0.081	0.142			0.2234
91			0.262			0.2616
92			0.235	0.001		0.2359
93			0.246	0.008	0.000	0.2533

4. In 1985, when the new varieties were first adopted, existing techniques had production costs around 30,000 FCFA/ha, while the new techniques cost around 50,000 FCFA/ha, for a level of adoption cost (dC) around 20,000 FCFA/ha. These adoption costs then declined gradually, as improved agronomic packages became available. Note that, as before, adoption costs are expressed in real terms by dividing the observed (nominal) prices by a price index.

AGRONOMIC DATA (CONTINUED)

Adoption costs (dC), in real terms

	Prod. Costs (FCFA/ha)	Adoption Costs (FCFA/ha)	Adoption Cost (dC) (Real) (FCFA/ha)	Prices Nominal (FCFA/kg)	Price Index ('93=1)	Prices (Real) [P]
85	50000	20000	19474	69.4	1.027	67.58
86	47257	17257	15847	99.6	1.089	91.46
87	47257	17257	16530	99.8	1.044	95.59
88	47257	17257	16836	99.7	1.025	97.27
89	42412	12412	12050	99.7	1.030	96.80
90	42412	12412	12015	99.8	1.033	96.61
91	41936	11936	11760	99.9	1.015	98.42
92	41936	11936	11760	100.0	1.015	98.52
93	41936	11936	11936	99.2	1.000	99.20

6. To move from adoption costs per hectare to proportional adoption costs, we can follow the formula: c=(dC*T)/(Ym*P).

Proportional increase in costs [c=(dC*T)/(P*Ym)])

	L 299	Irma 9697	Irma 1243	Stam F	Stam 42	Total
85	0.28	0.00				0.28
86	0.24	0.00				0.24
87	0.13	0.03				0.16
88	0.00	0.13				0.13
89		0.12	0.01			0.12
90		0.04	0.07			0.10
91			0.12			0.12
92			0.10	0.00		0.10
93			0.11	0.00	0.00	0.11

7. It is now necessary to incorporate supply and demand elasticities. We assume a very low supply elasticity (E=0.3) to reflect the small potential for increased area or input use, and a high demand elasticity (e=10) to reflect the fact that the price of cotton is determined in a very large world market. The k parameter is computed by dividing j by E and by subtracting c from the result. The increase in production (dQ) is computed using the formula: dQ=(Q*e*E*k)/(E+e), and social gains are computed using the formula SG=(k*P*Q)-(.5*k*P*dQ).

ECONOMIC DATA

E =	0.3	(Supply elasticity)
e =	10.0	(Demand elasticity)

SUPPLY SHIFTS AND SOCIAL GAINS FROM RESEARCH

	Parameter "k"	dQ (t)	Social Gain (FCFA millions)
85	-0.028	-381530	-89
86	0.127	1029738	317
87	0.212	1655453	527
88	0.545	6162512	1895
89	0.736	8292749	2461
90	0.642	5478981	1647
91	0.756	9851891	2962
92	0.682	10048796	3061
93	0.732	10136290	3084

9. Next, it is necessary to subtract the costs of research and extension, adjusted for inflation by dividing costs, in nominal terms, by the price index. The net social gain, in real terms, is computed by subtracting the program costs from the gross social gains obtained in step 8. Finally, the Internal Rate of Return (IRR) is computed using the Lotus or Quattro formula @IRR using the net social gain data from 1984 to 1993.

NET SOCIAL BENEFITS AND THE RETURNS TO RESEARCH

	Research Costs	Extension Costs	Total Costs	Real Total Costs	Net Social Benefits	Internal Rate of Return
	(Millions of FCFA)			(FCFA'93)	(FCFA'93)	(IRR):
83	25.1	50.0	75	92	-92	95.7%
84	25.1	50.0	75	83	-83	
85	25.1	114.8	140	136	-225	
86	37.5	96.2	134	123	195	
87	62.1	63.1	125	120	407	
88	60.6	71.5	132	129	1766	
89	60.6	95.5	156	152	2309	
90	58.5	59.9	118	115	1533	
91	58.5	107.3	166	163	2799	
92	60.0	109.4	169	167	2895	
93	60.0	110.9	171	171	2913	