



Impact assessment of mobile app using Economic Surplus Model

VINAYAK NIKAM¹, SHIV KUMAR² and KINGSLEY I T³

ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi 110 012, India

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ABSTRACT

This article assesses the economic benefits of mobile app that provides real time information as well as forecasting about weather, pest and diseases of the grape crop in Maharashtra, India. Results of Economic Surplus Method (SME) showed that over the period of 16 years (2007–2022), 20% adoption of mobile app would generate total surplus of ₹ 9140.85 million and Net Present worth of ₹ 9111.94 million. Internal Rate of Return (IRR) would be 316%, indicating higher economic return from the technology of mobile app. At 50% level of adoption, it would generate total surplus of ₹ 13271.42 million with IRR of 317 per cent. The size of these returns implies that mobile based app for the grapes has high potential of economic return; returns on investments in extension services are quite attractive and there is scope for increasing outreach of information to realize the potential of technology in agriculture sector.

Key words: Economic surplus, Grape cultivation, Impact assessment, Information Communication Technology, Mobile app

Information plays important role in the improved decision making of the farmers leading to increase in yield (Birtal *et al.* 2015) and reduction in the cost of cultivation (Ake 2003). To be effective, information must be relevant, complete and meaningful to farmers; packaged and delivered in a way preferred by them (Diekmann *et al.* 2009); and should be context specific (Sammadar 2006). Information failures in public sector extension systems have reduced extension impact limited feedback and reach to farmers reduced content relevance (Anderson and Feder 2004). To overcome this problem, Information Communication and Technology (ICT) can be used to disseminate the information to large number of farmers, reduction in transaction costs and enabling farmers in taking timely quality decision in agriculture (Park 2004 and Lomas 2000), to reduce agricultural losses, forecast productivity, and enhance production with proper vertical integration of the production centres and the markets (Ake 2003, Chumjai 2006), education and training, monitoring and consultation and access to government database (Mangina 2005).

In India, only 40% Indian farmers have access to information about agriculture (NSSO 2013). Mobile phone has lot of potential to reach out vast number of farmers as mobile phone penetration was 77% in rural areas (IAMAI

2018) and internet users reached 500 million (CMIE 2018). Accessibility of mobile phones helped in reducing physical and social marginalisation of poor regions and people, by facilitating communication as per demand and reducing the transaction cost (Balasubramanian *et al.* 2002, Molony 2006, Jensen 2007, Abraham 2007). Qiang *et al.* (2012) described qualitative as well as quantitative advantages mobile applications in agriculture.

Present study analyses impact of Mobile app developed by National Research Centre for Grapes, Pune in Maharashtra state of India and now commercialised by S K Crop Tech Company. App provides complete information and decision support system for farmers to take appropriate action. It provides weather information and forecasting for coming days (up to one week), based on data received from the Automatic Weather Stations at farmers' field that covers 50 sq km area each. The Disease and Pest Forecast System tells in advance the farmers what diseases and pests may occur to the planted crops.

Considering the potential of mobile app, study was undertaken to analyse the impact of mobile app using economic surplus method at state level.

MATERIALS AND METHODS

Study area, Sampling and data collection: Study was carried out with the grape growers from Nashik and Sangli districts of Maharashtra. A triangulation approach was followed which includes use of both qualitative and quantitative methods and primary as well as secondary data. A multistage sampling procedure was followed. Maharashtra, which is largest producer of grapes in India

Present address: ¹Scientist (vinayakrnikam@gmail.com), ²Principal Scientist (shivkumardull@gmail.com), ³Scientist (ecokingsly@yahoo.co.in), ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi.

was selected purposively. Nashik and Sangli districts of Maharashtra were selected based on maximum users of the mobile app. From each district 350 adopters and 50 non-adopters of the app were selected. Personal interview of the farmers was conducted to collect that data about personal, socio-economic variables, cost of cultivation and production. The time series secondary data on production and market price of grapes were accessed from online data archives of government of India (www.data.gov.in).

Economic surplus analysis: Economic analysis was conducted to assess the aggregate level of benefits and distribution of benefits of mobile app at state level using an economic surplus method. This method relies on the principle of projecting shifts in supply and demand curves based on changes in yield and input cost due to adoption of technology. Changes in economic surplus that included producer and consumer surplus were calculated, then discounted (10%) and totaled over 16 years to provide estimate of economic benefits of the technology. Assumption of “closed economy” was maintained as about 90% of the grapes are consumed domestically. The basic economic surplus model of research benefits is described by Alston, Norton and Pardey (1995) (Fig 1).

D (Fig 1) represents the demand for the product, yield improvement or reduction in cost following adoption of the new technology is represented by the shift in supply from S_0 to S_1 . The initial equilibrium price and quantity are P_0 and Q_0 ; P_1 and Q_1 represent after the supply shift. The area beneath the demand curve and between the two supply curves ($\Delta TS = \text{area } I_0abI_1$) represents the total (annual) benefit from the research induced supply shift (Alston, Norton and Pardey 1995, pp. 209-210).

Total surplus is calculated by

$$\Delta CS = P_0 Q_0 Z (1 + 0.5Z \eta) \quad (1)$$

$$\Delta PS = P_0 Q_0 Z (K - Z) (1 + 0.5Z \eta) \quad (2)$$

$$\Delta TS = \Delta CS + \Delta PS = P_0 Q_0 K (1 + 0.5Z \eta) \quad (3)$$

ΔCS , change in consumer surplus; ΔPS , change in producer surplus; ΔTS , change in total surplus; P_0 , the price before the introduction of mobile app; Q_0 , the pre-research quantity; η , the elasticity of demand.

$$Z = K\epsilon / (\epsilon + \eta) \quad (4)$$

$$K = [E(y)/\epsilon - E(c)/1 + E(y)] p A (1 + \partial) \quad (5)$$

Z , reduction in price, relative to its initial value, due to supply shift; η , absolute value of the elasticity of demand; ϵ , elasticity of supply; K , proportionate shift down in the supply curve due to the technology; $E(y)$, expected yield change; $E(c)$, expected cost change; P , probability of research success; A , technology adoption rate; ∂ , technology depreciation rate.

For estimation of economic surplus, it requires data on production, prices in real term, price elasticities of supply and demand, expected yield increases and reduction in cost, probability of research success, time to complete the research, adoption rates, and discount rate. To calculate net

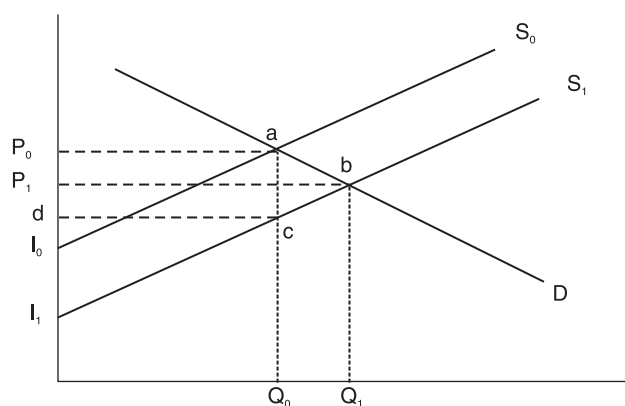


Fig 1 Economic surplus measurement.

benefits, information on research and development costs is also needed. We accessed the production and price data for grapes for Maharashtra state from government of India website www.data.gov.in. Data related to yield and cost changes were obtained using data of survey conducted in Nashik and Sangli districts of Maharashtra. The probability of success of the mobile app research was considered 50% considering the risk component involved.

Research on mobile app was started in the year 2007 and it was developed and commercialized in 2012. Adoption of the mobile app was started in 2012 with 800 farmers adopting the app, which reached 5000 in 2016. Assuming the standard adoption curve (Rogers 2003) and after discussion with company officials managing the app, adoption rate was assumed to be 20% in 2022. Demand and supply elasticities represent the responsiveness of supply and demand to changes in price. Demand and supply elasticities were obtained from the literature review (Kumar 2010). Research costs (₹) from 2007 to 2012 were obtained from official records of ICAR-NRC Grapes Pune. Development and maintenance cost of the app was obtained from S K Croptech Company Pvt Ltd, which had commercialized the product. Net benefits were calculated by using the economic surplus formula. Benefits and costs were calculated, discounted at 10% and summed to obtain a net present value.

RESULTS AND DISCUSSION

Personal and socio-economic characteristics of adopter and non-adopters of mobile app: Village adoption rate of the mobile app was higher in adopter (6.67%) village as compared to non-adopter villages. Adopters had significantly higher level of education and annual income than the non-adopters. Those adopted the app had more number of smart phones in household than farmers not adopting the mobile app. Adopter of the mobile app had allocated less per cent (61.81%) of area to the grapes out of total area than the non-adopter (68.75%) (Table 1). Adopter of the mobile app had less farming experience than the non-adopter of the app. This may be because less experience compels farmers to seek information from different sources and adoption of mobile app. Landholding of adopter farmers was more as

Table 1 Personal and socio economic characteristics of adopter and non-adopters

Variable	Adopter (n=700) 87.5 %	Non adopter (n=100) 12.5 %	Total (n=800)	Difference
Village adoption rate (%)	6.67 (4.05)	2.70 (2.07)	6.17 (4.06)	3.97***
Age (Years)	40.94 (9.78)	43.56 (9.97)	41.27 (9.83)	-2.62***
Family size (Number of members in family)	6.44 (2.41)	6.29 (2.03)	6.42 (2.36)	0.15
Education (Years of schooling)	13.09 (2.44)	11.84 (1.73)	12.93 (2.40)	1.25***
Land holding (acre)	3.52 (2.31)	2.94 (1.65)	3.44 (2.24)	0.58**
Cast (Percentage of farmers belong to general cast)	82.72	90	83.63	
Farming experience (years)	14.37 (6.37)	15.20 (8.67)	14.47 (6.70)	-0.83
Area under grapes (%)	61.81(29.68)	68.75 (30.80)	62.67 (29.89)	-6.94**
Household income (Million ₹ per annum)	1.45 (1.23)	1.05 (1.06)	1.39 (1.21)	0.39***
Number of smart phone in household	1.82 (0.84)	1.52 (0.64)	1.75 (0.82)	0.3***

Figures in parenthesis indicate the standard deviation, *, ** and *** Indicate that difference between adopters and non-adopters is statistically significant at 10, 5 and 1 percent level respectively using non parametric Mann-Whitney U test.

compared to non-adopter farmers.

Economic surplus analysis: Results of economic surplus represent difference between monetary value of the unit consumed and the monetary value of unit produced up to the equilibrium price and quantity. Different value parameters were used in estimation of economic surplus (Table 2). Value of increase in yield and change in cost of cultivation (variable cost) before and after adoption of mobile app was taken from the survey conducted with the grape growers. The increase in yield of the grapes as result of adoption of mobile app was 11% while reduction in cost of cultivation was 13 per cent. This can be attributed to the reduction in loss because of timely management practices as per need and advice got through the app. Forecasting could help in reducing unnecessary spraying and could save machine as well as labour cost of the users of the app.

Maximum adoption rate till 2022 was considered 20% after consultation with the personnel of S K Crop Tech Company which owned the app. In 4 years (2012-16) adoption of mobile app could reach 15% showing take off in the adoption graph. With present rate, adoption can go higher than we considered till 2022. However, we have considered the factor that other private players are also likely to develop similar apps by seeing advantages of the app, therefore likely increasing competition from other players. Demand elasticity of grape was taken as -0.595 and supply elasticity as 0.4. Smaller elasticity implies steeper curves. A demand elasticity of -0.595 implies that a 1% price reduction increases the quantity demanded of grapes by 0.595 percent. A supply elasticity of 0.4 implies that a 1% increase in price increase the quantity supplied by only 0.4 percent.

Results of economic surplus method showed that, from its initial development (2007) to full commercialization (2017), this app could generate the net benefits of ₹ 2857.20 million with NPV value of ₹ 3844.04 million, total surplus of ₹ 3863.59 million with IRR 316 per cent. We also projected the benefits of the mobile app to the year 2022. Over the period of 2007 to 2022, this app would produce total surplus

Table 2 Value parameter used in estimation of economic surplus

Parameter	Value	Source
Increase in yield (%)	11	Own survey
Reduction in variable cost (%)	12	Own survey
Maximum adoption rate (%)	20	S K Crop Tech
Supply elasticity of grape	0.4	Review of literature
Demand elasticity of grape	-0.595	Kumar (2010)
Probability of success of the app	50	Expert opinion

(consumer surplus and producer surplus) of ₹ 9140.85 million, Net Present Value of ₹ 9111.94 million with net benefits of ₹ 4822.98 million (Table 3). One of the ways to look at the potentiality of investment is the internal rate of return (IRR) which provides an idea of potential profitability and quick recovery of investment, which must be more than 30% as benchmark value. Internal Rate of Return is 316%, indicates the use of mobile app as an economically viable and feasible option to farmers to increase their income. The results suggest that further investments on research in agriculture will generate significant returns and leads to the development of agriculture in the country.

Sensitivity analysis: To see the robustness of the results, the sensitivity analysis was performed for range of values of adoption rate and supply elasticity. Table 4 shows the estimated economic benefits at 20%, 30%, 40% and 50% adoption rate, i.e. the percentage of grape growers adopting the mobile based app, and 0.20, 0.40 and 0.60 level of supply elasticity. With the increase in adoption rate from 20 to 50%, IRR changes by 1% only (at supply elasticity 0.40), though total gain changes significantly from ₹ 9111.4-₹ 13242.51 million. Reduction in supply elasticity from 0.40 to 0.20 significantly increased the IRR (361) and NPV (₹ 15677.58 million), similar trend also found with increase in adoption rate. BIRTHAL *et al.* (2015) reported that those who use information from all sources realize 12% more net income/returns per ha than those who do not. A 12% higher net income per ha for users translated into an additional ₹ 1140/

Table 3 Net present value, internal rate of return and benefit-cost-ratio of Mobile app

Year	Adoption rate (%)	Change in total surplus (Million ₹)	Research and development Cost (Million ₹)	Net benefit (Million ₹)
1 (2007)	0.00	0.00	0.32	-0.32
2 (2008)	0.00	0.00	0.37	-0.37
3 (2009)	0.00	0.00	0.37	-0.37
4 (2010)	0.00	0.00	0.38	-0.38
5 (2011)	0.00	0.00	0.38	-0.38
6 (2012)	0.03	308.62	7.24	301.38
7 (2013)	0.03	443.53	5.74	437.79
8 (2014)	0.07	1882.96	7.14	1875.82
9 (2015)	0.10	1179.06	6.56	1172.50
10 (2016)	0.16	2799.74	6.66	2793.07
11 (2017)	0.16	2864.27	7.06	2857.20
12 (2018)	0.17	3255.76	6.86	3248.90
13 (2019)	0.18	3672.36	6.96	3665.39
14 (2020)	0.19	4114.07	7.06	4107.00
15 (2021)	0.19	4350.87	7.16	4343.71
16 (2022)	0.20	4830.24	7.26	4822.98
Net Present Value (NPV) (Million ₹)				9111.94
Internal Rate of Return (IRR) (%)				316
Producer surplus (Million ₹)				5466.13
Consumer surplus (Million ₹)				3674.71
Total surplus (Million ₹)				9140.85

Past values adjusted through WPI index (2005); Discount rate of 10%.

ha of cropped area (at 2002-03 prices). This was much higher than the expenditure on public extension services (₹ 29/ha), and also on the research and education (₹ 57/ha). Thus, findings suggest that returns on investments in extension services are quite attractive, and there is scope for increasing outreach of information to realize the potential of technology in agriculture sector. The under investment in agricultural extension services would limit the realization of potential generated in agricultural technology via Research and Development system in the country.

Indian agriculture has stood the test of time, despite facing constraints on resources to the competing goals and programs which was possible through development and dissemination of technology. Efforts are made to make the system more responsive and effective in achieving specified goals and objectives. This entails scrutiny of limited resources on regular basis and their allocation to potential areas/activities to yield better results. Timely and location specific information helps the farmers take action that results into less cost, more efficient resource use and increase in the yield. Large economic benefits of the app at aggregate level would accrue to the farmers in Maharashtra from wider adoption of mobile app. Higher IRR of 316% indicates higher economic return from the

Table 4 Sensitivity of estimate for different assumption

Maximum adoption level of mobile app by 2022 (%)	Supply elasticity	NPV (Million ₹)	IRR (%)	Total Surplus (Million ₹)
20	0.20	15677.58	361	15706.49
20	0.40	9111.94	316	9140.85
20	0.60	6923.56	296	6952.47
30	0.20	19382.3	361	19411.21
30	0.40	11266.95	316	11295.86
30	0.60	8562.10	296	8591.02
40	0.20	23394.17	361	23423.08
40	0.40	13600.02	316	13628.93
40	0.60	10335.74	296	10364.65
50	0.20	27939.29	361	27968.19
50	0.40	13242.51	317	13271.42
50	0.60	12344.24	296	12373.15

technology of mobile app. Considering the uncertainty farmers face regarding weather, pest and disease under the changing climatic situation, the mobile app giving real time information as well as forecasting based on locality of the farmers can play important role in reducing risk and maximizing yield and income of the farmers. Government should play more active role in promotion of such apps in other crops also, as installation of automatic weather stations involves huge cost and farmers may not afford to install it. More educated farmers having higher annual income may be targeted for promotion of ICT based interventions. Group based approach like farmers based organization may be used as village adoption rate significantly affected the adoption of mobile app indicating influence of social learning on adoption of new technology.

Biophysical, social scientists and research managers worked together to build the system more responsive within existing conditions. The research partnerships between various institutions have been observed which often involves working with private agencies and farmers. Such partnership helps optimize resource use, develop synergies and pursue a demand-driven technology agenda. In case of mutual interest, public institutes work with private companies for commercialization of technologies and benefits are shared in the framework developed for management of intellectual property rights. To sustain the benefits in future, there will be need for allocation of more resources for research and also fostering linkages between stakeholders and development agencies to accelerate dissemination of technology.

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REFERENCES

- Abraham R. 2007. Mobile phones and economic development: Evidence from the Fishing Industry in India. *Information Technology and International Development*, 4(1): 5–17.
- Ake K, Clemons J, Cubine M and Lilly B. 2003. *Information Technology for manufacturing: reducing costs and expanding capabilities*. CRC Press.
- Alston J M, Norton G W and Pardey P G. 1995. *Science under Scarcity: Principles and Practices for Agricultural Research Evaluation and Priority Setting*. Cornell University Press, Cornell.
- Anderson J R and Feder G. 2004. *Agricultural Extension: Good Intentions and Hard Realities*. World Bank Research Observer 19(1): 41–60.
- Balasubramanian S, Peterson R A and Jarvenpaa S L. 2002. Exploring the implications of Mobile commerce for markets. *Journal of the Academy of Marketing Science* 30(4): 348–61.
- Birthal P, Kumar S, Negi D and Roy D. 2015. Impact of information on returns from farming. Policy paper 29, ICAR-National Institute of Agriculture Economics and Policy Research, New Delhi.
- Chumjai P. 2006. *Farmers' organization approach: An alternative to effective extension in Thailand*. International workshop on effective methods of disseminating new technology considering the viewpoint of farmers, Taiwan.
- CMIE. 2018. Urban and rural subscriber base in telecommunication infrastructure. Centre for Monitoring Indian Economy, Mumbai. (<http://www.cmie.com>).
- Dickmann F, Loibl C and Batte M T. 2009. The economics of agricultural information: factors affecting commercial farmers' information strategies in Ohio. *Review of Agricultural Economics* 31(4): 853–72.
- IAMAI. 2018. Internet users projected to cross 500 million by June 2018. Available from <http://www.iamai.in/media/details/4990>.
- Jensen R. 2007. The Digital Divide: Information (Technology), Market Performance and Welfare in the South Indian Fisheries Sector. *Quarterly Journal of Economics* 122(3): 879–924.
- Lomas J, Milford J R and Mukhala E. 2000. Education and training in agricultural meteorology: Current status and future needs. *Agricultural and Forest Meteorology* 103: 197–208.
- Mangina E and Vlachos I P. 2005. The changing role of information technology in food and beverage logistics management: beverage network optimisation using intelligent agent technology. *Journal of Food Engineering* 70(3): 403–20.
- Molony T. 2006. I Don't Trust the Phone; It Always Lies: Trust and information and communication technologies in Tanzanian micro- and small enterprises. *Information Technologies and International Development* 3(4): 67–83.
- NSSO. 2013. 70th Round, Situation assessment survey of Agricultural households: All India Debt and Investment & Land and Livestock Holdings in India (January 2013–December 2013), Ministry of Statistics and Programme Implementation, Government of India.
- Park T A and King R P. 2004. Evaluating Food Retailing Efficiency: The Role of Information Technology. The Sloan Foundation and the Food Industry Center.
- Qiang C Z, Kuek S C, Dymond A and Steve E. 2012. *Mobile Applications for Agriculture and Rural Development*. ICT Sector Unit. World Bank.
- Rogers E M. 2003. *Diffusion of Innovations*. 5th Edn. Free Press, New York.
- Samaddar A. 2006. Traditional and post-traditional: A study of agricultural rituals in relation to technological complexity among rice producers in two zones of West Bengal, India. *Journal of Culture and Agriculture* 28(2): 108–21.