INSTITUTO INTERAMERICANO DE COOPERACION PARA LA AGRICULTURA

PRIMER SEMINARIO SOBRE INVESTIGACION Y DESARROLLO TECNOLOGICO EN EL SECTOR AGROPECUARIO COLOMBIANO

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PALABRAS PRONUNCIADAS POR EL DIRECTOR DE PROEXPO EN LA REUNION PREVIA AL SEMINARIO SOBRE INVESTIGACION AGROPECUARIA

Es indiscutible la importancia que dentro de las exportaciones nuevas del país ocupan las del sector agropecuario, habiendo generado en los últimos años más del 25% del total de las divisas que hemos recibido por este concepto. Es así como de 249.4 millones de dólares exportados en 1976 se pasó a 425.5 millones en 1980. De otra parte Proexpo ha considerado en sus Programas Operativos Anuales como una necesidad fundamental la de estimular el desarrollo y tecnificación de la producción con el fin de aumentar la oferta exportable y mejorar sus condiciones de competencia.

Teniendo en cuenta estas circunstancias el Fondo de Promoción de Exportaciones decidió participar activamente en la organiz ación de esta reunión en el entendido de que las decisiones y recomendaciones que adopte serán de la mayor conveniencia para el país y para el futuro del comercio exterior de productos agropecuarios.

Ciertamente, como lo señala el Plan Nacional de Integración, una de las estrategias fundamentales para acelerar el crecimiento y desarrollo del sector agropecuario es la

de incrementar de manera sustancial la productividad de todos los recursos empleados en el sector, de tal manera que el país pueda contar con una fuente permanente de crecimiento de la producción de alimentos y materias primas agropecuarias, no sólo para el consumo interno sino para la exportación.

Desafortunadamente no son satisfactorios los niveles de productividad de los productos agropecuarios de exportación, que actualmente estamos colocando en los mercados externos como es el caso del ajonjolí, el algodón, el tabaco y la ganadería, para citar unos pocos. Ello se debe a diferentes factores de orden tecnológico, como la falta de programas de mejoramiento genético, el mal manejo de plagas y de enfermedades y el deficiente uso de otros factores que participan en la producción, aspectos éstos que están conduciendo a una pérdida constante de su competitibidad en los mercados externos.

Por otra parte, es igualmente preocupante la ausencia de investigación y, por ende, de una tecnología adecuada para la producción de otros productos con interesantes perspectivas de exportación. Tal es el caso de las frutas tropicales, las hortalizas, los palmitos, los peces ornamentales, las especies de flora y fauna, la cría de camarones en cautiverio y otros rubros de no menor importancia, sin olvidar que algunos de esos productos pueden entrar a hacer parte fundamental de la dieta del pueblo colombiano, enriqueciendo sus hábitos de alimentación y supliendo en parte sus necesidades nutricionales.

Para todos ellos, es preciso desarrollar sistemas modernos y rentables de producción adaptados a nuestras propias condiciones. Igualmente se hace necesario mejorar el

manejo postcosecha, la clasificación, empaque y el almacenamiento de productos, sobre todo de los llamados perecederos.

La investigación debe obedecer a programas coherentes y estables que conduzcan a una adecuada producción agropecuaria. No basta la simple formulación de los programas, sino que es indispensable crear mecanismos adecuados de coordinación entre las diferentes entidades públicas y privadas, que permitan el desarrollo de los mismos con agilidad hasta lograr los objetivos que se persiguen los cuales deben consultar las verdaderas necesidades del país. Por ello la conveniencia de establecer un modelo que permita determinar las prioridades, para destinar a esos productos los mayores esfuerzos de investigación, lo cual asegura la mayor rentabilidad de la inversión desde el punto de vista social y la continuidad en su ejecución.

Obviamente, surgen al profundizar en este esfuerzo inquietudes relacionadas con el costo y las posibles fuentes de financiamiento de la investigación, sobre la necesidad de contar con profesionales capacitados para adelantarla y con la provisión de laboratorios, equipos y demás recursos físicos, sin los cuales sería imposible pensar en investigación agropecuaria. Estas inquietudes e interrogantes deben obligatoriamente tener eco y respuesta en los sectores público y privado y sugieren la necesidad de iniciar un proceso de concertación sobre esta materia, teniendo en cuenta que , la

investigación es la mejor inversión que puede hacer el país en el mediano y en el largo plazo.

Proexpo, más que programas de investigación propiamente dichos, ha ejecutado, con la colaboración de organismos nacionales e internacionales, diversos proyectos orientados a mejorar el desarrollo tecnológico de algunos productos agropecuarios, con el objeto de iniciar o de incrementar sus exportaciones. A este respecto se efectuó con el apoyo de la Comunidad Económica Europea un estudio de factibidad para la producción de "scargots", se desarrollaron programas de asistencia técnica en apicultura, con la colaboración del Programa de Diversificación de las zonas cafeteras y de expertos en organismos internacionales y se elaboraron un afiche y un catálogo sobre cortes de carne tipo exportación, conjuntamente con la Universidad Nacional.

Igualmente productores de espárragos, champiñones, bocadillos, melones, flores, cueros y maderas, en una u otra forma se han beneficiado de programas adecuados por Proexpo con miras a aumentar y diversificar la oferta agropecuaria del país.

Es importante además señalar, cómo, especialmente el crédito de mediano y largo

plazo que ha otorgado el Fondo para el sector agropecuario, ha contribuído a hacer un mejor uso de los factores de producción y a lograr, en algunos casos, como es el del cultivo del banano en la Zona de Urabá, incrementos apreciables en la productividad.

Recientemente la Junta Monetaria mediante la Resolución 28 estableció una línea de crédito cuyos recursos provienen tanto del Fondo Financiero Agropecuario como de Proexpo para financiar el desarrollo de minidistritos de riego pues se ha considerado que uno de los limitantes de la actividad agropecuaria en Colombia es la abundancia o escasez de los recursos hídricos. La infraestructura que se financiará con estos recursos debe contribuir a obtener una mayor productividad en el sector.

Proexpo es consciente de las limitaciones de las acciones enunciadas anteriormente pues han sido aisladas y han obedecido preferencialmente a la presión de la demanda externa por algunos bienes agropecuarios. Por ello considera que las que proyecta realizar en el futuro deben estar enmaracadas en un programa de investigación agropecuaria que consulte las conveniencias señaladas en un programa general del país, dentro de las cuales las del sector exportador tienen una marcada importancia. Dentro de este marco, el Fondo seguirá canalizando en beneficio del sector las ayudas que pueda obtener de organismos internacionales y haciendo aportes

directos para proyectos específicos sobre productos de exportación.

Adicionalmente está dispuesto a financiar parcialmente las investigaciones que se adelanten en productos actuales o potenciales de exportación, mediante convenios que suscriban las agremiaciones con el ICA, las Universidades, y otras entidades que estén capacitadas para realizarlas. Igualmente podrá financiar aquellas investigaciones que grupos de empresarios, o las mismas agremiaciones, desarrollen con miras a implantar avances tecnológicos encaminados a lograr aumentos de productividad. Tales iniciativas deben necesariamente complementarse con mecanísmos de difusión a fín de que éllas sean adoptadas por los agricultores.

Esperamos una respuesta positiva del sector privado a los anteriores planteamientos, que no dudamos contribuirán al mejor desarrollo del sector agropecuario nacional.

Para alcanzar una mayor claridad sobre las circunstancias que rodean la investigación, se ha preparado un cuestionario para ser discutido en esta reunión, al cual se le debe dar un amplio debate.

Las conclusiones de este Foro serán remitidas a los participantes y servirán de base a la ponencia que el Dr. Armando Samper presentará en el Seminario a desarrollarse en la Sede del CIAT, el próximo mes de abril. Este evento organi-

zado conjuntamente por el Ministerio de Agricultura, el Departamento Nacional de Planeación y Colciencias, que cuenta con el apoyo de diversas instituciones públicas y privadas, tendrá una marcada importancia para el desarrollo de esta actividad en Colombia, pues sus conclusiones serán base para el desarrollo de la estrategia a seguir por el gobierno nacional.

Agradezco su presencia en este recinto y les deseo éxitos en las deliberaciones.

SUBCOMISION INVESTIGACION Y TRANSFERENCIA

RECOMENDACIONES

1. INTRODUCCION.

Esta subcomisión considera que la motivación que alimente las recomendaciones para el sector como un todo, debe ser redactada y presentada por la comisión central del sector. En Consecuencia, el énfasis sobre motivaciones que se presenta a continuación, se refiere sólo al tema de Investigación y Transferencia de Tecnología.

2. MOTIVACION.

En Colombia el desarrollo económico y social está basado primordialmente en el sector agropecuario. Asimismo las innovaciones tecnológicas son el pilar fundamental para permitir este desarrollo.

El producto de la investigación, debidamente incorporado al proceso productivo, se constituye en la mayor fuente de posibilidades para el logro de mejorar el ingreso del productor y obtener niveles de producción suficientes en calidad y cantidad. De igual manera este proceso le asegura a la población, productos a precios relativos más bajos y provisión permanente, lo cual repercute en un mayor bienestar.

Lo anterior significa que, debidamente orientado, el proceso de investigación y transferencia, aplicado al sector productivo, representa para Colombia la mayor fuente de crecimiento económico y de bienestar social.

3. REQUISITOS.

Para que el proceso de Investigación y Transferencia cumpla con su objetivo en el sector agropecuario y el país, se demanda el cumplimiento de los siguientes requisitos:

.1. Que obedezca a un plan diseñado para solucionar los principales limitantes del sector productivo.

.2. Que tenga un modelo institucional apropiado.

.3. Que tenga continuidad y estabilidad a largo plazo.

.4. Que cuente con recursos humanos suficientes en cantidad y calidad, además de una política de incentivos que asegure su permanencia.

.5. Que tenga los mecanismos y fuentes para su adecuada financiación.

.6. Que cuente con los recursos físicos y la infraestructura especializada, acorde a sus requerimientos.

.7. Que el sistema administrativo y fiscal sea ágil y eficiente.

.8. Que esté entregando soluciones a los productores, en forma continua, oportuna y eficaz.

4. RECOMENDACIONES.

.1. "PLANIA":

Al reconocer la importancia del Plan Nacional de Investigaciones Agropecuarias del ICA (PLANIA), se recomienda su inmediata institucionalización legal como estrategia indispensable e instrumento esencial y permanente para la orientación de la Investigación Agropecuaria.

.2. Reorganización del ICA:

Separar las funciones de investigación y transferencia institucional, de las de regulación, Fomento, control y normalización, actualmente en el ICA, creando dos entidades diferentes e implementando el modelo institucional que ellas requieren. Se

pretende con esta acción evitar el antagonismo, competencia e ineficiencia de tales funciones cuando se ejecuten dentro de una sola institución.

.3. Investigación y desarrollo:

Se recomienda que las funciones de investigación y transferencia institucional permanezcan juntas, debidamente coordinadas y enmarcadas dentro de planes técnicamente elaborados, que garanticen su continuidad y estabilidad, y en los cuales se reconozcan objetivos armónicos con la política general del sector. Es esencial establecer mecanismos para que la Universidad Colombiana se vincule más estrechamente al proceso de investigación, teniendo en cuenta su disponibilidad de recursos humanos altamente calificados.

.4. Financiación:

Para que los planes de investigación y de transferencia puedan ejecutarse, se recomienda que el Gobierno Nacional cree los mecanismos precisos que aseguren su financiación: Presupuesto Nacional, recurso externo, gravámenes a las importaciones y exportaciones agropecuarias, fondos de comercialización, Ley 5a., CAT, Fondo Financiero Agropecuario, Fondo de Fomento Agropecuario, etc. Se enfatiza la concertación que debe procurarse entre el ICA y otras entidades públicas y privadas para la ejecución y financiación de la investigación y transferencia. Esto debe conducir a acciones tales como el Convenio recientemente firmado con COLCIENCIAS, el cual permitirá al ICA disponer de recursos adicionales para sus labores de Investigación.

.5. Participación del Sector Privado:

Se recomienda adoptar un mecanismo de participación del sector gremial privado (industrial y agropecuario) en las acciones de investigación y transferencia de los organismos oficiaoes, preferenciaomente a través de contratos debidamente formalizados, en los cuales no solamente se especifique el aporte financiero, sino también la intervención en la asignación de recursos y la supervisión en la ejecución de los mismos. Esto permitirá al sector privado concentrar sus esfuerzos especialmente en el fomento y desarrollo del producto agropecuario de su interés, utilizando los resultados de la Investigación.

.6. Especialización y Estímulo:

El Gobierno debe buscar la capacitación de los profesionales de investigación y transferencia, para asegurar la bondad y calidad de éstas. Igualmente, se deben implementar los incentivos necesarios para asegurar la permanencia de éstos en labores de investigación y transferencia.

.7. Infraestructura Física:

Se recomienda especial atención al mejoramiento de la infraestructura física para la investigación y transferencia, tanto en la dotación de la existente como en su ampliación y funcionamiento.

.8. Régimen administrativo y fiscal:

Se recomienda que las entidades responsables de la Investigación y Transferencia creen una estructura administrativa y fiscal ágil, acorde con las necesidades de la investigación y transferencia.

5. PARTICIPANTES.

Coordinación General:

Doctor Gustavo Barney López, Gerente General del Instituto Colombiano Agropecuario, ICA.

Participantes:

Gerentes Técnicos, directivos o representantes de las siguientes instituciones:

INCOMEX - CAJA AGRARIA - FEDERACAFE - FEDEGAN - CONALGODON - FEDERALGODON - CENICAÑA - FEDEARROZ - FENALCE - FEDEPALMA - FEDECACAO - FEDEPAPA - AUGURA - PLANEACION NACIONAL - S.A.C. - INCUBAR - U.T.C. - FANAL - UNIVERSIDAD NACIONAL - COLCIENCIAS - O.P.S.A. - BANCO GANADERO - I.C.A.

Bogotá, Noviembre de 1981.

República de Colombia

DEPARTAMENTO NACIONAL DE PLANEACION

BASES PARA EL PLAN NACIONAL DE INVESTIGACIONES DEL SECTOR AGROPECUARIO, FORESTAL Y PESQUERO

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BASES PARA EL PLAN NACIONAL DE INVESTIGACIONES DEL SECTOR AGROPECUARIO, FORESTAL Y PESQUERO

I. INTRODUCCION

La política agropecuaria, forestal y pesquera planteada en el Plan de Integración Nacional reconoce que una de las estrategias fundamentales para acelerar el crecimiento del sector es la de incrementar la productividad de los factores de producción utilizados en el área rural. Entre las medidas de política que contribuyen a este incremento de la productividad se encuentra, primero que todo, el apoyo a la investigación. Esta, de acuerdo con lo señalado en el PIN, ha encontrado obstáculos por la carencia de políticas claras en el mediano y largo plazo, así como en la falta de fondos adecuados para impulsarla.

Dentro de este marco, el objetivo del presente documento es el de plantear los lineamientos generales que conduzcan a la definición de una política tecnológica para el sector agrario y especificar los términos en que se deben crear el Consejo Nacional de Investigaciones y Desarrollo Tecnológico Agrario y el Fondo Nacional de Investigaciones y Desarrollo Tecnológico Agrario, propuestos en el PIN como elementos fundamentales para promover y encauzar la investigación en el sector agropecuario.

II. RESUMEN DEL DIAGNOSTICO

La investigación agropecuaria, forestal y pesquera en Colombia reviste características particulares por cuanto hay marcadas diferencias entre regiones, productos y tipos de productores, lo cual no ha permitido en muchos casos una aplicación generalizada, a los diferentes cultivos y especies, de las innovaciones tecnológicas.

En Colombia ha tenido lugar, a raíz de la llamada revolución verde, un considerable avance en materia de productividad agraria en los últimos decenios. Sin embargo, se ha detectado un amplio margen para continuar el avance en materia de investigación agropecuaria para casi todos los cultivos, en especial en el desarrollo y adaptación de tecnologías adecuadas y en la producción de variedades mejoradas y de razas más productivas.

A. INVESTIGACION AGROPECUARIA

El país ha obtenido resultados satisfactorios mediante la generación de nuevas variedades que, además de ofrecer altos rendimientos, tienen un período vegetativo más corto. Cabe destacar que hacia finales de 1979 el ICA había producido un total de 205 híbridos y variedades en 31 cultivos diferentes, entre los cuales se destacan los logrados en banano, cacao, cebada, fríjol, caraota, maíz, sorgo y trigo. A pesar de que se han logrado avances innegables, los rendimientos aún permanecen a niveles bajos en comparación con los obtenidos por nuestros competidores en los mercados externos.

Los cultivos asociados a zonas de minifundio muestran una mayor brecha tecnológica y por tanto presentan una amplia potencialidad aparente, destacándose los casos del maíz, el trigo, la papa y el fríjol. En los casos del arroz y la soya, cuyos rendimientos están entre los más altos de América Latina, existe todavía un potencial de mejoramiento si se les compara con los observados en el contexto mundial.

La brecha de productividad anteriormente señalada hace pensar que los servicios de asistencia técnica no tienen el suficiente impacto. En efecto, este servicio cubre apenas un 34% del área cultivada, con énfasis en arroz, algodón, soya, maíz y papa y con una alta concentración en las zonas DRI.

En relación a la ganadería, la productividad ha permanecido estancada, muy por debajo de los niveles de eficiencia posibles. La brecha tecnológica en la producción de carne es bastante amplia y entre las limitantes tecnológicas se destacan los aspectos que tienen que ver con la alimentación, el manejo, la sanidad y el mejoramiento genético.

B. INVESTIGACION FORESTAL Y PESQUERA

En el campo de la silvicultura se han logrado algunos avances en el planeamiento y mejoramiento genético, aunque éstos se han limitado a un número reducido de especies. En los últimos años se han iniciado programas de investigación y ya se comienza a hablar de la actividad agrosilvipastoril, o sea la combinación del establecimiento de bosques con cultivos agrícolas y actividades pecuarias. Estos programas son la base para desarrollar sistemas tecnológicos adecuados a las actuales áreas de colonización y zonas minifundistas de vocación forestal.

Con contadas excepciones, no se ha hecho investigación en el manejo de los bosques naturales y los pocos trabajos existentes son en su mayoría de carácter descriptivo. Por su parte, los actuales sistemas de aprovechamiento son notoriamente ineficientes ya que se desperdicia más de un 35% del volumen maderable y se dejan de explotar numerosas especies por desconocimiento de sus posibilidades de utilización.

Cabe destacar que la investigación forestal se caracteriza por el largo plazo de su maduración y que por lo tanto requiere de continuidad no siempre encontrada en el actual sistema institucional.

En relación al subsector pesquero, la investigación es definitivamente escasa, siendo prioritario obtener un conocimiento más preciso del recurso en cuanto a su ubicación y cuantificación. Así mismo, el sistema de pesca artesanal es de muy bajo nivel tecnológico, y en él predominan patrones tradicionales en las artes y metodologías de pesca, evidenciándose el requerimiento de un proceso acelerado de transferencia de tecnología. Tal situación es generalizada y aún en el caso de la pesca industrial se tiene un nivel de adopción tecnológica muy bajo a pesar de que se dispone de algunas técnicas modernas.

C. ASPECTOS INSTITUCIONALES

La revitalización de la investigación agropecuaria requiere de una reorientación institucional, sobre todo a nivel del aparato estatal, con el fin de coordinar y concertar las acciones que adelanta el país en materia de desarrollo tecnológico.

Desde el punto de vista institucional, merecen destacarse dos aspectos principales. En primer lugar, aproximadamente el 80% de la investigación en Colombia la efectúa el ICA. En segundo lugar, no se ha contado con el necesario señalamiento de prioridades para distribuír los pocos recursos disponibles para la investigación y la transferencia de tecnología en el sector agrario. En general, la determinación de prioridades ha dependido principalmente de situaciones coyunturales y la necesidad de obtener resultados a corto plazo ha impuesto un criterio inmediatista en la toma de decisiones.

1. Papel del ICA, INDERENA y CONIF

Durante la última década se han venido asignando al ICA funciones diferentes a las de investigación, extensión y docencia que le son propias. Tal es el caso de las labores de fomento a la producción que se relacionan con las campañas sanitarias, la asistencia técnica y la colocación de crédito; las actividades de control que tienen que ver con la certificación de semillas y supervisión de insumos y otras acciones como las construcciones rurales, la microinfraestructura y la sanidad portuaria.

El ICA es el único instituto de investigación en América Latina que tiene a su cargo labores administrativas como las mencionadas. La diversidad de sus funciones, la competencia interna por recursos que tiene lugar entre ellas, y la ineficiencia generada por estos factores, hacen pensar que el actual modelo institucional es inapropiado.

Las funciones adicionales han implicado mayores presiones sobre los recursos de la institución puesto que ellas no han venido acompañadas de los correspondientes aportes en el presupuesto nacional, los cuales se han mantenido dentro del mismo orden de magnitud en términos reales. Esto ha obligado al Instituto a distraer sus esfuerzos hacia la búsqueda de mayores recursos propios, labores que compiten en términos de recursos humanos y financieros con las actividades científicas de la institución.

Además de la escasez de recursos disponibles para el INDERENA y CONIF, a través del tiempo, para la investigación forestal, la labor del primero de ellos ha evidenciado falta de continuidad, debilitando así el liderazgo que debe ejercer. En este instituto también se ha desarrollado la dualidad entre las funciones de control, vigilancia y fomento, por un lado, y la labor de investigación y extensión, por el otro, siendo por ello cuestionable la actual estructura institucional.

2. Prioridades de la Investigación

La inexistencia de un esquema general que defina las prioridades a nivel nacional y que consolide la información sobre las investigaciones que se están realizando y que se pretenden realizar, ha llevado a que tenga lugar una duplicidad de esfuerzos, una disparidad de criterios y una baja utilización de la capacidad instalada. Tal situación sugiere que los recursos de origen estatal deben ser asignados a la luz de las prioridades de los Planes de Desarrollo sin que por ello se entorpezca la actividad investigativa de quienes desearían realizarla con sus propios medios. En efecto, en el último decenio, paralelo al proceso de estancamiento de la investigación oficial, se ha producido un favorable desarrollo de la investigación llevada a cabo por el sector privado.

III. OBJETIVOS

A. OBJETIVOS GENERALES

El objetivo prioritario del Plan es el desarrollo y la provisión de tecnología apropiada que promueva el cambio tecnológico y mejore la productividad de los recursos empleados en el sector rural, con el fín de reforzar el abastecimiento de alimentos y materias primas a precios competitivos. Adicionalmente, la investigación debe estimular la generación de una oferta exportable creciente que permita aprovechar al máximo las oportunidades del mercado internacional y coadyuvar, así, al mejoramiento de los ingresos reales del productor en forma tal que auspicie su permanencia en el agro.

En segundo lugar, el plan debe suministrar elementos para racionalizar y canalizar la inversión pública y privada en el área de investigación, definiendo criterios para seleccionar los proyectos prioritarios del sector, de forma tal que se incremente la tasa de rentabilidad social de esta actividad.

B. OBJETIVOS ESPECIFICOS

Se persiguen los siguientes objetivos específicos:

1. Proponer un esquema para establecer las prioridades para la investigación agropecuaria, forestal y pesquera, tanto de corto como de largo plazo, que partiendo de criterios socioeconómicos y tecnológicos, permita hacer un uso eficiente de los recursos disponibles para esta actividad.

2. Diseñar un Sistema Nacional de Investigaciones agropecuarias, forestales y pesqueras que integre en forma coordinada los esfuerzos de las entidades nacionales e internacionales, públicas y privadas, y los oriente hacia objetivos comunes en este campo dentro del marco de la política sectorial.

3. Proponer las reformas institucionales y las políticas relacionadas que sea necesario adelantar con el fín de adecuar la estructura técnico-administrativa de las entidades oficiales que hacen parte del sistema nacional de investigaciones.

4. Proponer una política de recursos humanos para la investigación en el sector agrario que contemple mecanismos de capacitación y formas de remuneración acordes con la condición del investigador.

5. Diseñar mecanismos de coordinación y financiación para la ejecución y evaluación de los proyectos de investigación y para la captación de recursos financieros en forma contínua.

IV. LINEAMIENTOS GENERALES DE UNA POLITICA TECNOLOGICA AGRARIA

Como resultado del diagnóstico, se sugieren una serie de lineamientos básicos que encaucen la acción de las entidades dedicadas a la investigación y a la transferencia de tecnología en el sector.

El criterio fundamental, especialmente para las entidades estatales, consiste en que la investigación tecnológica debe seguir una línea de política que consulte principalmente metas de tipo socio-económico. Para un país en desarrollo como Colombia, el gasto en investigación es una inversión de la cual hay que obtener el mayor provecho, tanto desde el punto de vista de los beneficios privados que acompañan a los aumentos en productividad, como desde el punto de vista del beneficio social que se obtiene de ésta. En esa forma, las metas del Plan Nacional de Ciencia y Tecnología deben derivarse de las políticas del plan de desarrollo.

La traducción de los objetivos del desarrollo social y económico en directrices para la investigación tiene en la selección de prioridades un instrumento fundamental. A pesar de los limitados recursos de que actualmente dispone la investigación, éstase caracteriza por una amplia dispersión debido a la excesiva cantidad de productos y temas de los que se ocupa. Con la selección se trata de orientar ordenadamente gran parte de los escasos recursos disponibles hacia los productos de mayor significación socio-económica relativa, sin descuidar las labores correspondientes a los demás. Con ello se trata de asegurar una mayor efectividad en la obtención de resultados significativos desde el punto de vista de la producción nacional.

En cuanto a los productos identificados, cada uno de ellos tiene su propia problemática tecnológica, en términos de limitantes, del grado de esos limitantes y del esfuerzo que es necesario realizar para superarlos. La determinación de prioridades de investigación, entonces resulta de la confrontación de dos aspectos: el socio-económico, que evalúa la importancia de cada producto e interpreta las políticas de desarrollo y, el tecnológico, que estudia el carácter y la magnitud de los limitantes que lo afectan. En este sentido, el aspecto tecnológico debe ser lo suficientemente amplio y flexible como para permitir su confrontación con el factor socio-económico y de esta forma obtener una visión global de las prioridades.

Por otro lado, la problemática tecnológica y socio-económica de la producción agraria está determinada, en gran parte, por las particularidades de su localización regional. Por lo tanto, la programación de la investigación deberá tener en cuanto los aspectos de regionalización, tanto en la fase de diagnóstico como en la fase de ejecución, pues el país se encuentra dividido en grandes regiones naturales, dentro de cada una de las cuales existen zonas agroecológicas homogéneas. La identificación y caracterización de éstas permitirá una asignación más eficiente de los recursos de investigación y también el desarrollo del proceso multiplicador de los resultados.

La investigación agraria no debe limitarse a los aspectos biológicos o a la producción de variedades mejoradas sino que debe tener en cuenta otras fases del proceso agrario, en especial lo referente a las técnicas de manejo posteriores a la cosecha con el objeto de minimizar las cuantiosas pérdidas físicas en esta etapa del proceso y mejorar la comercialización y el almacenamiento. Así mismo, se deben explorar las posibilidades agroindustriales buscando dar localmente el mayor valor agregado posible al producto.

La cercana relación entre los sectores agrícola e industrial, tanto en lo referente a la tecnología de alimentos como a los subsectores industriales que producen insumos para las faenas agrícolas, implica que las decisiones tecnológicas comunes deben beneficiar a ambas actividades. En esta forma, los desarrollos tecnológicos deben apuntar hacia una producción de materias primas de la calidad que requiere la industria y los productores de insumos deben desarrollar la tecnología apropiada a nuestras condiciones de producción.

El tipo de tecnología que corresponde a cada país o a cada región está, en parte, determinado por las condiciones únicas y específicas en lo que hace a la dotación relativa de recursos productivos, a sus condiciones económicas y sociales y al tipo específico de suelo y clima en que se desarrolla la actividad agropecuaria. Por ello, la importación de tecnología de otros países requiere especial cautela para seleccionar la clase de conocimientos generados en el exterior que conviene introducir y adaptar a nuestros procesos de producción.

Una de las principales condiciones para el éxito de la investigación es su continuidad. En este sentido, el horizonte de planeamiento de esta actividad en el campo agrícola debe ser amplio, buscando dar mayor estabilidad a la gran cantidad de proyectos que usualmente superan los cuatro años, factor especialmente válido para el sector forestal.

En cuanto a la transferencia de tecnología, los mecanismos actualmente disponibles en el país han sido diseñados primordialmente para atender a productores empresariales vinculados estrechamente al mercado. Sin embargo, en países como el nuestro existen amplias capas de pequeños productores que enfrentan problemas estructurales y altos riesgos que dificultan la adopción tecnológica. Tales productores proveen buena parte de la oferta alimentaria y de materias primas forestales, razón por la cual es necesario insistir en hacerlos también beneficiarios del cambio tecnológico, desarrollando sistemas de transferencia ajustadas a su racionalidad y a sus medios.

En general, la investigación sin una exitosa transferencia de tecnología carece de sentido práctico y no produce los resultados esperados en términos de incremento de la producción y la productividad. Cuando la adopción es baja, la explicación puede estar en que los incentivos de precios a los productores son inadecuados o los insumos muy costosos. Por esta razón, los esfuerzos realizados para fortalecer la investigación deben acompañarse de medidas que contribuyan a crear un ambiente económico atractivo para las actividades agropecuarias, en particular con respecto a precios y costos de los insumos. Así mismo, los paquetes tecnológicos generados deben consultar la capacidad económica de los potenciales usuarios.

V. MEDIDAS DE POLITICA

A. SISTEMA NACIONAL DE INVESTIGACIONES Y DESARROLLO TECNOLOGICO DEL SECTOR AGRARIO

La adecuada implantación del Plan Nacional de Investigaciones del Sector Agrario requiere la estructuración y puesta en marcha de un modelo institucional que, de una parte, garantice la disponibilidad de fondos y agilidad para desembolsos, y de otra, disponga de un órgano de alto nivel que asesore al Gobierno en lo relacionado con la formulación, orientación y evaluación de las políticas tecnológicas en el sector agropecuario. Conforme a lo anterior, se creará el Sistema Nacional de Investigaciones y Desarrollo Tecnológico, integrado por los siguientes componentes :

- En su estructura operativa, por las entidades públicas directamente responsables de la ejecución de la política tecnológica agraria (ICA e INDERENA) con el apoyo de CONIF, el HIMAT, el Instituto Geográfico Agustín Codazzi, los otros institutos del sector que efectúen investigación, las universidades públicas y privadas, las Secretarias de Agricultura, los centros privados de investigación agropecuaria, los centros internacionales de investigación, y de otros organismos similares que puedan participar en actividades del sistema.

- En su estructura directiva y coordinadora, por el Ministerio de Agricultura, el Departamento Nacional de Planeación y el Consejo Nacional de Investigaciones y Desarrollo Tecnológico del Sector Agrario.

- En su estructura financiera, por los recursos de las entidades del Sistema y por el Fondo Nacional de Investigaciones y Desarrollo Tecnológico del Sector Agrario.

1. Consejo Nacional de Investigaciones y Desarrollo Tecnológico Agrario

Este organismo está llamado a jugar un papel de primordial importancia para orientar las labores del Sistema, a través de su asesoría al Ministerio de Agricultura y el Departamento Nacional de Planeación, en la definición de un esquema de prioridades y la formulación de políticas de investigación y desarrollo tecnológico para el sector agrario en el mediano y largo plazo. Como tal, el Consejo servirá fundamentalmente como un medio de concertación entre las entidades públicas, y entre éstas y las entidades privadas que ejecutan investigación y labores de transferencia de tecnología en el sector. En este sentido, desarrollará una acción orientada a evitar la duplicación y paralelismo de funciones y a clarificar los objetivos de cada entidad involucrada en el Sistema Nacional, organizando y coordinando los esfuerzos del país en materia de investigación científica y tecnológica para el sector agrario.

Para el cumplimiento de estos objetivos, el Consejo operará como un organismo asesor, adscrito al Ministerio de Agricultura, compuesto por representantes del Gobierno, de la comunidad científica y de los gremios, que tendrá, entre sus funciones, la distribución global de los recursos del Fondo Nacional de Investigaciones. Así mismo, el Consejo tendrá una Secretaría Técnica que será desempeñada por COLCIENCIAS, la cual estará encargada de analizar, evaluar y presentar al Consejo los planes y programas que sean sometidos a consideración de este organismo, el cual asignará los recursos del Fondo para los proyectos específicos, sujeto al programa de operaciones que al respecto apruebe el Consejo. Al final de cada ejercicio fiscal, el Consejo presentará al Ministerio de Agricultura, por intermedio de la Secretaría Técnica, un informe de sus actividades.

2. Fondo Nacional de Investigaciones y Desarrollo Tecnológico Agrario

Este Fondo constituirá un mecanismo para el financiamiento de algunas de las actividades investigativas consideradas prioritarias en el Plan Nacional. Su inclusión en el Sistema responde, de una parte, a la insuficiencia de los recursos destinados a la investigación, y de otra parte, a la necesidad de contribuír a mantener un flujo permanente, regular y ágil de recursos que permita la ejecución en forma contínua de los proyectos de investigación prioritarios para el país. Por esta razón, el Fondo debe contar con recursos adicionales a los que actualmente disponen las entidades participantes en el Sistema. En su aspecto operacional, funcionará como una cuenta especial del "Fondo Colombiano de Investigaciones Científicas y Proyectos Especiales Francisco José de Caldas", COLCIENCIAS. En tal caso, los recursos del Fondo de Investigaciones solo podrán destinarse a las actividades que determine el Consejo, y su manejo se orientará mediante un convenio de administración con COLCIENCIAS. Así mismo, a través de este Fondo, las Universidades podrán contar con recursos diferentes a los de su presupuesto para desarrollar proyectos de investigación en el sector agrario.

B. REORDENAMIENTO INSTITUCIONAL

Para posibilitar el funcionamiento del modelo institucional propuesto y el cumplimiento de los objetivos del Plan Nacional de Investigaciones, se buscará un reordenamiento institucional de las entidades encargadas de la investigación, en especial de la estructura técnico-organizativa del ICA y del INDERENA, los principales organismos ejecutores de las políticas de investigación, transferencia de tecnología y educación técnica en el Sector Agrario, con el fin de que asuman el liderazgo que se requiere para estimular el funcionamiento del Sistema y para facilitar la adecuada ejecución del Plan.

C. PARTICIPACION DEL SECTOR PRIVADO

El Consejo establecerá mecanismos que aseguren la participación del sector privado con el propósito de que se canalicen esfuerzos hacia el fomento y desarrollo de productos agropecuarios específicos, en una forma consistente con los requerimientos del sector productivo. Esta participación del sector privado se hará dentro del marco de prioridades definido por el Consejo Nacional de Investigaciones.

El apoyo del sector privado, además de su participación en el Consejo, debe referirse básicamente al aporte de recursos financieros y humanos para fortalecer investigaciones desarrolladas por las entidades oficiales y a convenios entre éstas y el sector privado para adelantar investigaciones específicas.

De otra parte, deben estudiarse con cuidado los proyectos de creación de centros privados de investigación especializados cuando éstos requieran asignaciones de recursos oficiales. Para su consideración, estos proyectos deben demostrar su factibilidad en términos de sus costos y beneficios, en relación con aquellos resultantes de la investigación que se realiza utilizando la capacidad instalada de los centros existentes de investigación.

D. POLITICA DE RECURSOS HUMANOS

El personal técnico-científico para la investigación tiende a constituírse en un recurso escaso debido a la calidad requerida y al tiempo necesario para formar investigadores. De ahí la importancia de definir una clara política de recursos humanos para la investigación. Esta política se refiere básicamente a un plan de capacitación de personal y a un mecanismo para remunerar a los investigadores de una manera competitiva en el mercado laboral.

Los planes de capacitación determinarán la necesidad de profesionales universitarios del país en los diferentes niveles y disciplinas agropecuarias, forestales y pesqueras. Así, las entidades ejecutoras de la política de investigación contarán con programas de capacitación para investigadores que incluyan planes de educación formal y entrenamiento en servicio, lo cual se hará conforme a las políticas y prioridades del Gobiemo en materia de investigación.

Así mismo, las unidades administrativas de apoyo a la investigación en las diferentes entidades tendrán mecanismos que permitan mejoras en la remuneración real de los investigadores. A este respecto, se estudiará la posibilidad de que las diferentes entidades tengan un régimen especial en materia de clasificación y salarios, debidamente aprobado por el Servicio Civil. Este tipo de medidas será la única manera, en el largo plazo, de retener investigadores y atraer a estas actividades personal profesional altamente calificado.

La coordinación entre las Universidades y las otras entidades participantes en el sistema permitirá que la preparación de profesionales se desarrolle de acuerdo a las necesidades de investigación del país, haciendo énfasis en la investigación aplicada con preferencia sobre aquella puramente teórica.

E. FINANCIACION

El presupuesto asignado a cada entidad componente del Sistema será la fuente básica para la financiación del Plan y el Fondo Nacional de Investigaciones se constituirá en una fuente complementaria de los recursos de presupuesto para investigación.

Con el objeto de disminuír la inestabilidad de los recursos para investigación se requiere una fuente que los genere en forma permanente y regular y por ello se buscará que el Fondo de Investigaciones se financie con dineros provenientes de los Fondos de Comercialización y Fomento Agropecuario cuyo proyecto de ley cursa en el Congreso. Mientras se define la estructura de éstos, debe estudiarse la posibilidad de contar con recursos del presupuesto nacional, PROEXPO, donaciones y cooperación técnica internacional. Así mismo, el Fondo manejará los ingresos provenientes de los créditos externos actualmente en proceso de contratación por COLCIENCIAS, en la parte pertinente a la investigación agropecuaria, forestal y pesquera.

VI. ESQUEMA INSTITUCIONAL

En primer lugar, siguiendo los criterios establecidos en este documento, el Ministerio de Agricultura, con la colaboración del Departamento Nacional de Planeación y COLCIENCIAS, creará y reglamentará el Consejo y el Fondo Nacional de Investigaciones y Desarrollo Tecnológico Agrario.

En segundo lugar, las principales entidades gubernamentales que sean miembros del Sistema Nacional, y especialmente el ICA, el INDERENA y la Universidad Nacional, tanto como las instituciones privadas que así lo deseen, procederán a elaborar, o continuarán elaborando, sus respectivos planes de investigación 1/. Estos programas serán presentados a consideración del Ministerio de Agricultura y el Departamento Nacional de Planeación quienes se encargarán de estructurar los planes agropecuarios, forestal y pesquero y concertarlos con entidades públicas y privadas, los gremios y representantes de los consumidores. El Consejo constituirá un foro donde se discutan los planes y actuará como organismo asesor del Gobierno. En tercer

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1/ El ICA, que ha elaborado su respectivo Plan, debe revisarlo a la luz de los criterios señalados en este documento.

lugar, el Ministerio de Agricultura y el Departamento Nacional de Planeación elaborarán, para consideración del CONPES, una propuesta concreta acerca del mecanismo que permitirá captar recursos adicionales y permanentes para el Fondo. En cuarto lugar, el Ministerio de Agricultura, conjuntamente con las entidades que estime conveniente, conformará un grupo de trabajo para elaborar una propuesta de reestructuración institucional de la función de investigación en el ICA y el INDERENA, la cual será presentada a consideración del CONPES. En quinto lugar, el ICA y el INDERENA elaborarán una propuesta acerca de un régimen especial de clasificación y salarios para los investigadores de dichas entidades, la cual será presentada por el Ministerio de Agricultura al Departamento Administrativo del Servicio Civil para su estudio y aprobación.

MINISTERIO DE AGRICULTURA
DEPARTAMENTO NACIONAL DE PLANEACION

FONDO COLOMBIANO DE INVESTIGACIONES CIENTIFICAS Y PROYECTOS ESPECIALES "FRANCISCO JOSE DE CALDAS" -COLCIENCIAS-

PRIMER SEMINARIO SOBRE INVESTIGACION Y DESARROLLO TECNOLOGICO EN EL SECTOR AGROPECUARIO COLOMBIANO

Con el auspicio de :

ICA, PROEXPO, FONADE, CENICAÑA,
SAC, CIAT, CIID, IICA, ISNAR.

Cali, 21-23 de abril de 1982

COMITE ORGANIZADOR :

DR. FERNANDO LONDOÑO CAPURRO	-	Ministro de Agricultura
DR. FEDERICO NIETO TAFUR	-	Jefe Departamento Nacional de Planeación
DR. EFRAIM OTERO RUIZ	-	Director Fondo Colombiano de Investigaciones Científicas y Proyectos Especiales - COLCIENCIAS -.
DR. ROBERTO JUNGUITO BONNET	-	Presidente Sociedad de Agricultores de de Colombia -SAC -.
DR. ARMANDO SAMPER GNECCO	-	Director Centro Nacional de Investigaciones de la Caña de Azúcar -CENICAÑA -.
DR. MANUEL J. CARDENAS ZORRO	-	Director Fondo de Promoción de Exportaciones -PROEXPO -.
DR. GUSTAVO BARNEY LOPEZ	-	Gerente General Instituto Colombiano Agropecuario - ICA -.

TEMARIO Y AGENDA DE TRABAJO

21 de Abril

8:30 a.m.	Acto de Instalación.
	Palabras del Doctor John Nickel, Director del CIAT.
	Palabras del Doctor Gustavo Barney, Gerente General del ICA.
	Palabras del Doctor Efraím Otero Ruíz, Director General de COLCIENCIAS.
	Instalación del Seminario a cargo del Doctor Federico Nieto Tafur, Jefe del Departamento Nacional de Planeación.

Tema de las exposiciones del día:

MARCO TEORICO PARA LA INTERPRETACION DEL CAMBIO TECNOLOGICO EN LA ACTIVIDAD AGROPECUARIA

9:00 a.m.	La Innovación Inducida como Interpretación del Cambio Tecnológico en el Desarrollo Agrícola de los Países en Desarrollo.
	Ponente: Doctor Vernon Ruttan.
9:45 a.m.	Comentarios a cargo de: Doctor John Lynam
9:55 a.m.	Sesión de preguntas.
10:15 a.m.	Café
10:30 a.m.	Cambio Técnico en el Sector Agropecuario de América Latina: Un Intento de Interpretación.
	Ponente: Doctor Martín Piñeiro
11:15 a.m.	Comentarios a cargo de: Doctor Manuel Ramírez
11:25 a.m.	Sesión de preguntas.
12:00 m.	Almuerzo
2:15 p.m.	Economía Política de la Investigación Agrícola y del Cambio Tecnológico.

	Ponente: Doctor Alain de Janvri
3:00 p.m.	Comentarios a cargo de: Doctor Roberto Junguito.
3:10 p.m.	Sesión de preguntas.
3:30 p.m.	Café
3:45 p.m.	La Teoría Económica del Financiamiento de la Investigación Agrícola. Ponente: Doctor Eduardo Trigo
4:30 p.m.	Comentarios a cargo de: Doctor Jorge García
4:40 p.m.	Sesión de preguntas.
7:00 p.m.	Comida
8:00 p.m.	Mesa redonda sobre las conclusiones y recomendaciones derivadas de las discusiones del primer día.

22 de Abril

Tema de las exposiciones del día:

PRIORIDADES Y COOPERACION PARA LA INVESTIGACION AGROPECUARIA

9:00 a.m.	Organizaciones Internacionales para el Desarrollo y Financiamiento de la Investigación Agrícola y su Relación con los Sistemas Nacionales.
	Ponente: Doctor José Valle-Riestra.
9:45 a.m.	Comentarios a cargo de: Doctor Rafael Mariño.
9:55 a.m.	Sesión de preguntas.
10:15 a.m.	Café
10:30 a.m.	La Función y Posibilidades del Esfuerzo Cooperativo e Intercambio Técnico entre Instituciones Nacionales de Investigación Agropecuaria.
	Ponente: Doctor Edmundo Gastal.
11:15 a.m.	Comentarios a cargo de: Doctor Eduardo Trigo.
11:25 a.m.	Sesión de preguntas.
12:00 m.	Almuerzo
2:15 p.m.	Elementos Requeridos para que la Investigación Cumpla su Objetivo de Impactar el Desarrollo Agropecuario.
	Ponente: Doctor Hernán Chaverra.
3:00 p.m.	Comentarios a cargo de: Doctor Santiago Fonseca
3:20 p.m.	Sesión de preguntas
3:40 p.m.	Café
3:55 p.m.	Asignación de Prioridades a la Investigación Agropecuaria en Colombia.
	Ponente: Doctor Gabriel Montes
4:40 p.m.	Comentarios a cargo de: Doctor Germán Valenzuela Doctor Alvaro Silva

5:00 p.m.	Sesión de preguntas.
7;00 p.m.	Comida
8:00 p.m.	Mesa redonda sobre las conclusiones y recomendaciones derivadas de las discusiones del segundo día.

23 de Abril

Tema de las exposiciones de la mañana:

LA ORGANIZACION INSTITUCIONAL DE LA INVESTIGACION AGROPECUARIA EN COLOMBIA Y LA PARTICIPACION DEL SECTOR PRIVADO

9:00 a.m.	La Organización Institucional de la Investigación Agrícola en Colombia y el Plan Nacional de Investigaciones Agropecuarias. Ponente: Doctor Jaime Navas
9:45 a.m.	Comentarios a cargo de: Doctor Jaime Jiménez Doctor Jorge Ardila Doctor Guillermo Anzola
10:05 a.m.	Sesión de preguntas.
10:25 a.m.	Café
10:40 a.m.	La Función del Sector Privado en la Organización y Financiamiento de la Investigación Agropecuaria en Colombia. Ponente: Doctor Armando Samper
11:25 a.m.	Comentarios a cargo de: Doctor Carlos Ossa Doctor Ricardo Villaveces
11:45 a.m.	Sesión de preguntas.
12:15 m.	Almuerzo
2:15 p.m.	Presentación de las Conclusiones y Recomendaciones Generales del Seminario.
3:15 p.m.	Café
3:30 p.m.	Mesa Redonda Final sobre Conclusiones y Recomendaciones Generales del Seminario. Participantes: Doctor Virgilio Barco Vargas Doctor Germán Botero de los Ríos Doctor Cesar Gaviria Doctor Hugo Palacios Doctor Juan Camilo Restrepo Doctor Antonio Urdinola

5:15 p.m. Clausura.

Palabras del Doctor Roberto Junguito, Presidente de la Sociedad de Agricultores de Colombia.

Palabras del Doctor Luis Fernando Londoño Capurro, Ministro de Agricultura.

Lista de Invitados

1. Dr. Gabriel de Jesús Acevedo
2. Dr. Jorge Ahumada
3. Dr. Enrique Alarcón
4. Dr. Eduardo Alvarez Luna
5. Dr. Antonio Alvarez Restrepo
6. Dr. Gilberto Arango Londoño
7. Dr. Alvaro Araújo Noguera
8. Dr. César H. Arias Pabón
9. Dr. Jaime Ayala Ramírez
10. Dr. Gustavo Balcázar M.
11. Dr. Fernando Barberi
12. Dr. Francisco Barreto
13. Dr. Alberto Bernal Correa
14. Dr. Javier Bernal
15. Dr. Helmut Bickenbach Plata
16. Dr. Enrique Blair
17. Dr. Jaime Borrero Rengifo
18. Dr. Hernán Borrero Urrutia
19. Dr. Rodrigo Botero Montoya

20. Dr. Eduardo Brieva Bustillo
21. Dr. Julián Buitrago
22. Dr. Elkim Bustamante
23. Dr. Carlos Caballero
24. Dr. Alcides Caicedo
25. Dr. Rafael Caicedo Espinosa
26. Dr. Manuel José Cárdenas
27. Dr. Julio Carrizosa Umaña
28. Dr. Clímaco Cassalett
29. Dr. Eugenio Castro Borrero
30. Dr. Alex Cobo
31. Dr. Eugenio Concha
32. Dr. Gustavo Dajer Ch.
33. Dr. Sergio Durán
34. Dr. Hernán Echavarría Olózaga
35. Dr. Martín Echavarría
36. Dr. Silvio Echeverri Echeverri
37. Dr. Henry Eder Caicedo
38. Dr. Rodrigo Escobar Navia
39. Dr. Enrique Ezcurra
40. Dr. Mauricio Fernández
41. Dr. Hugo Ferreira Neira
42. Dr. Rafael Gama Quijano
43. Dr. Jaime García Parra
44. Dr. Alvaro Garner

45. Dr. Alvaro Gómez Hurtado
46. Dr. Guillermo Alberto González
47. Dr. Arturo Gómez Jaramillo
48. Dr. Antonio Guerra de la Espriella
49. Dr. Alfredo Gutiérrez
50. Dr. Ramsés Hakim Murad
51. Dr. Antonio Hernández
52. Dr. Armando Hernández
53. Dr. Enrique Holguín
54. Dr. Hernán Jaramillo
55. Dra. Nhora Pombo de Junguito
56. Dr. Horacio Linçe
57. Dr. Rodrigo Lince Tenorio
58. Dr. César Lobo
59. Dr. César Londoño
60. Dr. Raúl Londoño
61. Dra. Cecilia López de Rodríguez
62. Dr. Luis Lorente
63. Dr. Carlos Lleras Restrepo
64. Dr. Oscar Marulanda Gómez
65. Dr. Hugo Mazuera E.
66. Dr. Oscar Mazuera G.
67. Dr. Hernán Mejía Salazar
68. Dr. Jorge Mejía Salazar
69. Dr. José Mejía Salazar
70. Dr. Gabriel Melo Guevara

71. Dr. Carlos Montero
72. Dr. Rodrigo Múnera
73. Dr. Víctor Muñoz
74. Dr. Ernesto Muñoz O.
75. Dr. Gustavo Nores
76. Dr. César Ocampo Palacio
77. Dr. Francisco Ortega
78. Dr. Rafael Ospina
79. Dr. Jorge Ospina Sardi
80. Dr. Aquileo Parra
81. Dr. Heraldo Paternina
82. Dr. Enrique Peñalosa
83. Dr. Jorge Hernán Pineda
84. Dr. Omar Pinzón
85. Dr. Diego Pizano
86. Dr. Adriano Quintana Silva
87. Dr. Augusto Ramírez
88. Dr. Pedro José Ramírez
89. Dr. Eliseo Restrepo Londoño
90. Dr. Luis Romano
91. Dr. Jorge Rodríguez Arbelaez
92. Dr. Juan Camilo Restrepo
93. Dr. Arturo Sarmiento Angulo
94. Dr. Eduardo Sarmiento Palacio
95. Dr. Cristian Terraza
96. Dr. José María de la Torre

97. Dr. Diego Tobón

98. Dr. Manuel Torregrosa

99. Dr. Ricardo Torres

100. Dr. Emilio Trigueros

101. Dr. Fernando Umaña Rojas

102. Dr. Antonio José Uribe Portocarrero

103. Dr. Jaime Uribe Urdinola

104. Dr. Carlos Alfonso Valderrama

105. Dr. Hugo Valdés

106. Dr. Joaquín Vallejo Arbeláez

107. Dr. Alberto Vargas M.

108. Dr. Carlos Vergara Gómes-Casseres

109. Dr. Jorge Vivas Reyna

PONENTES Y COMENTARISTAS

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Teléfono: 683131

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PRIMER SEMINARIO SOBRE INVESTIGACION Y DESARROLLO TECNOLOGICO EN EL SECTOR AGROPECUARIO COLOMBIANO

CIAT, Cali 21 al 23 de abril de 1982

PALABRAS DEL DOCTOR GUSTAVO BARNEY

GERENTE GENERAL DEL ICA

SEMINARIO SOBRE INVESTIGACION AGROPECUARIA

Discurso: Dr. Gustavo Barney L.(*)

Toda nación que quiera desarrollarse para el bienestar de sus habitantes y quiera tener un liderazgo a nivel internacional, debe disponer de conocimiento crítico y generar su propia tecnología con miras a afrontar los limitantes existentes.

El sector agropecuario es el principal componente del sistema de alimentos, y sus múltiples articulaciones y eslabonamientos con los demás sectores ponen de manifiesto su importancia dentro de la economía en general del país. En efecto, el sector agropecuario contribuye actualmente con el 23 por ciento del PIB, genera el 17.2 por ciento de la remuneración salarial total y emplea la cuarta parte de los trabajadores del país. Asimismo, el 37.8 por ciento de su producción se procesa antes de llegar al consumidor final, la compra de insumos representa el 14 por ciento del valor de su producción, participa con un 80 por ciento en las exportaciones totales del país y con un 8 por ciento en las importaciones, constituyéndose en un exportador neto que genera la mayor parte de las divisas necesarias para el proceso de desarrollo.

Igualmente Colombia por su localización geográfica, con relación a los demás países del mundo, con los mares y su gran diversidad de condiciones eco-

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Gerente General del Instituto Colombiano Agropecuario, ICA.

lógicas debido a la presencia de las cadenas montañosas andinas y su recurso humano, tiene grandes ventajas comparativas con el resto de países del orbe.

Si en algún sector o actividad Colombia debe ser líder y original en cuanto al avance tecnológico, es en el agropecuario. No es que se desconozca la importancia de otros sectores en cuanto a que el país genere sus propios conocimientos, sino que siendo Colombia un país cuya verdadera vocación es la agropecuaria, es lógico desarrollar una tecnología autóctona para resolver los problemas de producción y productividad que actualmente poseen los productores.

El proceso de generación de tecnología, a través de la disciplina de investigación, es considerado universalmente como el elemento esencial para el desarrollo agropecuario de un país, no solamente por su impacto directo sobre la producción, sino por su efecto social sobre el recurso humano involucrado.

Es así como nuestro gobierno destaca en el Plan de Integración Nacional, PIN, que es necesario aumentar la producción agropecuaria y que para ello la investigación debe ser la principal herramienta para lograr dicha acción. Con este propósito plantea la necesidad de disponer del Plan Nacional de Investigaciones Agropecuarias, cuyas bases le fueron aprobadas por el CONPES. Sinembargo, debemos recalcar que, además del tecnológico, existen una serie de elementos complementarios indispensables para que la producción agropecuaria sea exitosa. Estos elementos corresponden a factores ecológicos, económicos y sociales. Estos factores interactúan y se complementan en su proceso de implementar la producción. La deficiencia que se pueda presentar en uno de ellos, necesariamente, causará un impacto negativo en el efecto final que de ellos se espera.

Por otra parte, estos elementos deben corresponder a acciones institucionales, con modelos apropiados. Dichos modelos deben estar debidamente estructurados, coordinados y ubicados de acuerdo a la naturaleza de los mismos para evitar efectos negativos y lograr, por el contrario, su fortalecimiento y desarrollo. Igualmente, ellos deben contemplar acciones de nivel nacional e internacional, tanto de carácter público como privado.

Para estar dentro del tema y objetivo del presente Seminario, debo enfatizar sobre todo en el proceso de investigación o generación de tecnología.

El Ministerio de Agricultura, desde hace muchos años, viene desarrollando esta labor, primero en la División de Investigaciones Agropecuarias (DIA) y desde 1963 en el ICA. Si bien es cierto que los logros obtenidos hasta el presente pueden calificarse de exitosos, también lo es que con el gran número de funciones asignadas por el gobierno a partir del año 1969, prácticamente bajo el mismo modelo institucional con el cual se creó el Instituto, se afrontan en el momento grandes dificultades de diverso orden, pero principalmente se pueden clasificar como de índole organizacional, presupuestal y administrativa.

A pesar de nuestro permanente deseo porque el país reciba oportunamente y con calidad, los beneficios de acuerdo con las funciones asignadas al Instituto, también hemos visto la necesidad de hacer un detenido análisis de la problemática existente y plantear al alto gobierno alternativas sólidas para el mejoramiento y fortalecimiento de los procesos de generación, transferencia y adopción de tecnología.

Para el Ministerio de Agricultura y el ICA, como coparticipantes en la organización de este Seminario y actuantes en el mismo, son de vital trascendencia las conclusiones y recomendaciones que del mismo se deriven. Manifiesto mi complacencia por la realización de este importante evento. Es difícil reunir, como se ha hecho, un notabilísimo y prestigioso grupo de conferencistas, comentaristas y participantes provenientes del exterior y de nuestro país. Las personalidades invitadas, algunas de ellas habiendo llegado a las más altas posiciones y distinciones que el Estado tiene, representan los diversos estamentos e intereses. Ellas, al estar reunidas en este Seminario, contribuirán a situar en un primer plano, la Investigación Agropecuaria.

Para el ICA, después del gran esfuerzo realizado al elaborar el Plan Nacional de Investigación Agropecuaria (PLANIA), este Seminario contribuirá a definir derroteros para buscar a nivel nacional, la debida implementación para las funciones que le fueron asignadas, pero fundamentalmente para el futuro de las actividades de Generación y Transferencia Tecnológica, razón inicial para la existencia del ICA.

Muchas gracias,

GUSTAVO BARNEY LOPEZ

Cali, 21 de abril de 1982.

Vernon W. Ruttan
Agricultural Research Policy
Minneapolis: University of Minnesota Press, 1982

Chapter 11

Research Resource Allocation

Should research be planned? The answer to this question often depends on the interpretation that the respondent attaches to planning.[1] The response is frequently confounded by the respondent's perception of the response to a second question: Who will have the authority for research planning? Researchers have often suggested, and with good reason, that the rates of return presented in table 10.3 place a major burden of proof on those who urge the use of more-formal planning methods to demonstrate that the resources devoted to planning will yield higher returns than the resources devoted to research.

Nevertheless, central management and planning staffs have been strengthened in most major national agricultural research systems during the 1960s and 1970s. (See chapter 4.) These more-intensive planning efforts have often been mandated by the legislative, financial, or planning bodies that are responsible for allocating resources to research. In the United States, for example, the Food and Agricultural Act of 1977 mandated the establishment of the Joint Council on Food and Agricultural Sciences in order to foster improved planning of federal and state agricultural research and the National Agricultural Research and Extension Users Advisory Board in order to attempt to reflect the priorities of both the users of research and those affected by research.

The planning staffs responsible for research resource allocation have not found it easy to respond to the expectations that their efforts would contribute both to greater efficiency in the use of research resources and to greater relevance in research resource allocation.

They have been pressed to respond to a succession of styles in analysis and planning: project and priority weighting or scoring of research objectives in the mid-1960s, program planning and budgeting in the late 1960s, systems analysis and simulation in the early 1970s, and the rhetoric of technology assessment in the mid-1970s. By the late 1970s, the program planning and budgeting methodology, which had temporarily fallen into disrepute as a result of the gap between promise and performance, had been resurrected under the rubric of zero-based budgeting.[2]

As planning activity has intensified, planning objectives have become more diverse. Concern with distributional impacts and environmental spillover has been added to the traditional concerns of quality of research performance and contributions to the productivity of the agricultural sector. It was no longer adequate to justify agricultural research in terms of making "two blades of grass grow where one grew before" or of increasing the productivity of farm workers by making it possible for a farm worker to cultivate twice as many acres in a day.

As research-planning staffs have struggled with the demands placed on them, it has become increasingly obvious that effective research planning requires close collaboration among natural and social scientists and among agronomists, engineers, and planners. This is because any research resource allocation system, regardless of how intuitive or how formal in its methodology, cannot avoid making judgments about two major questions.

What are the possibilities of advancing knowledge or technology if resources are allocated to a particular commodity, problem or discipline? If, for example, resources are allocated to the transfer, development, or enhancement of nitrogen-fixing capacity to grasses, what is the probability of success? The answers to such questions can only be answered with any degree of authority by scientists who are on the leading edge of the research discipline or problem being considered. The intuitive judgments of research administrators and planners rarely are adequate to answer such questions.

What will be the value to society of the new knowledge or the new technology if the research effort is successful? If efforts to develop nitrogen-fixing capacity in maize are successful, for example, will it become an efficient source of plant nutrition when evaluated in relation to the economic and environmental costs or other forms of nitrogen fertilizer? The answers to these questions require the use of formal economic analysis. The intuitive insights of research scientists and administrators are no more reliable in answering questions of value than the intuitive insights of research planners are in evaluating scientific or technical potential.

Many of the arguments about research resource allocations flounder on the failure of the participants to clearly recognize the distinction between these two questions and the differences in expertise and judgment that must be brought to bear on responding to them.

The purpose of this chapter is not to provide a technical exposition of research-planning methodology. Rather, it is to provide research administrators with a guide to, and an evaluation of, what can be expected from the planning methodologies available to them.

In the next section of the chapter, I discuss the parity or congruence model of research resource allocation that is implicit in much discussion of research resource allocation. I then give explicit attention to some of the considerations that determine the economic value of agricultural research and the distribution of gains from the productivity growth resulting from research. This is followed by a section that reviews some of the methodologies that might be used to select the individual research programs or projects that make up the research portfolio of a national agricultural research system or of an autonomous research institute.

This chapter is focused on the relatively narrow issue of the allocation of resources to production research. In chapter 13, I attempt to deal with some of the broader issues of social policy and agricultural research.

THE PARITY MODEL OF RESEARCH RESOURCE ALLOCATION

In chapter 10, substantial differences were noted in research expenditures relative to the values of individual commodities in the United States. In the cases of wheat and soybeans, the research expenditures in 1975 amount to about $2 per $1,000 of product. In the case of cotton, the research expenditures amount to about $15 per $1,000 of product. Were these ratios efficient? Were the expenditures on cotton too high? Were the expenditures on wheat and soybeans too low? When such figures are cited, there is often a presumption that the commodity characterized by a low research/output ratio is not getting its fair share of the research dollar. At a more sophisticated level, there is usually an implication that the return from an additional dollar would be highest if invested in research on the commodity with the lower research/output ratio. In either case, the critic usually has in mind, at least implicitly, what might be termed a "parity" model of research resource allocation.

The parity perspective is a useful first step in any analysis of research resource allocation. There are, however, two assumptions that are usually implicit in its application. The first assumption is that the opportunities for productive scientific effort or productivity-enhancing technical change are equivalent in each commodity and resource category. The second is that the value of a scientific or technical innovation is proportional to the value of the commodity or the value of the contribution of a particular resource to production.[3]

No one believes that either assumption is valid. Yet, in the absence of specific knowledge of research opportunities and payoffs, application of the parity model may not be entirely inappropriate. But even the parity rule may not be as simple to apply as one might suspect.

In agriculture the research resource allocation process involves a four-way allocation of resources: (1) among commodities, such as wheat, cotton, and beef; (2) among resource categories, such as soil and water, agricultural chemicals, labor, and management; (3) among stages or levels, such as industrial inputs, farm production, postharvest technology and markets, and community services; and (4) among disciplines, such as genetics, economics, and human nutrition. Even the concept of economic importance can easily become muddy. Should research resources be allocated between wheat production and bakery products in proportion to the market value of wheat and the market value of bakery products? Or should they be based on ratio of the value of wheat to the value added to the wheat by the baking industry? Should research dollars be allocated to livestock and livestock products in proportion to their market value or only in proportion to the value added by livestock to the feed they consume?

Whether one accepts the parity model as a primary criterion for the allocation of research resources or as a point of departure for the further fine tuning of research resource allocation, it would seem exceedingly important to be able to account for research expenditures in a manner that would permit accurate measures along the lines of the four dimensions outlined above. This would then permit the following parity or congruence calculations:

- A comparison of the ratio of research expenditure by commodity to the value added in farm production for each commodity.
- A comparison of the ratio of research expenditure by factor (or

resource) input to the cost or economic value of the factor (or resource) in production.

- A comparison of the ratio of research expenditure to the value added at each stage in the food production chain from purchased inputs to the consumer.
- A comparison of the ratio of research expenditure in each field of science to the value added for each commodity, factor, and stage.

Similar accounts should be accumulated in terms of scientist-years. This would permit comparisons of scientific effort as well as expenditures by factors, commodities, and stages. Capital investment in the form of facilities and major items of equipment should be reported separately from annual personnel and other operating costs.

The compilation of a set of research parity accounts does not imply a judgment that research resources should be allocated by a parity rule. It does not suggest that an explicit rationale should be developed for any departures from a parity rationale. Reasonable bases for such departures are not difficult to develop. A favorable judgment concerning the production potential of soybeans in 1940 or sunflowers in 1970 would have been a sound basis for a relatively high ratio of research to value added. A judgment that private-sector investment in farm machinery research and development is adequate could be a sound basis for a low ratio of research expenditures to the value of machinery services in farming. The rationale for a judgment that the ratio of research expenditures to the value of natural resource inputs should be higher than to the value of labor and managerial inputs may not be as obvious.

Regardless of the desirability of using the parity model as a first step in the analysis of research resource allocation, its use is feasible for only relatively gross comparisons even in countries with relatively well developed data systems. The U.S. Department of Agriculture, for example, publishes data on the value of commodity marketings. The data it publishes on the value of crop production are incomplete. The value of forage crops that are fed on the farm on which they are produced is not reported. Neither are data on the value added in the production of livestock and livestock products separately reported.

The research expenditure classifications that have been developed also have severe limitations. They seem to have been put together without a clear conception of their potential analytical uses. A three-way classification (1) among activities, (2) among commodities or resources, and (3) among fields of science was developed as part of the 1966 *National Program* study.[4] (See table 11.1.) A modification of this classification serves as a basis for the USDA's Current Research

Information System (CRIS). The original CRIS classifications came reasonably close to meeting the criteria outlined above in its commodity and field of science (discipline) classifications. The natural resource subcategory, however, includes both resource inputs (soils) and commodities (forest products). Information on interdisciplinary research efforts, such as integrated pest management, is difficult to identify and to retrieve. And the activity classification seems to have no clear-cut rationale for its categories.

Criticisms similar to those I have made with respect to the U.S. system also apply to a number of other systems. The analytical uses of information systems typically have become apparent after the systems have been put in place rather than at the design stage.

The next sections of this chapter are devoted to a more systematic review of some of the criteria that might be used as a basis for departures from the parity model of research resource allocation.

ALLOCATION OF RESOURCES TO RESEARCH

An implicit assumption of the parity model of research resource allocation is that the benefits from research are proportional to the size of the research budget and to the economic significance of the commodity sector or resource (factor) input to which the research effort is directed.[5] Such an assumption is clearly naive. Yet, one of the attractions of the parity model is that it does leave implicit rather than make explicit the specification of the size and distribution of the benefits from research.

Research administrators and policymakers have traditionally attempted to avoid overly precise specification of research objectives. They have preferred to be able to mobilize support from farmer clientele and clientele representatives by emphasizing the contributions of research to the reduction of production costs, to increases in yields, or to the adaptation of crops to different environments. Administrators have preferred, at the same time, to emphasize to other constituencies the gains to consumers in the form of lower food costs or the contributions of agricultural exports to the solution of balance-of-payments difficulties.

In nations characterized by strong organization among farmers, benefits to producers tend to be emphasized and benefits to consumers, muted. In countries where farmers are poorly organized, consumer benefits tend to be emphasized. Thus, in many developing countries with large but politically inert rural populations, the primary emphasis in establishing a claim to research resources is often

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Table 11.1. Classification Codesheet for Report of Agricultural Research for Fiscal Year Ending June 30, 1965

A. ACTIVITY

Conservation, Development and Use of Soil, Water, Forest, and Related Resources

1. Resources description and inventory
2. Resource conservation
3. Resource development and management
4. Evaluation of alternative uses and methods of use

Protection of Man, Plants, and Animals from Losses, Damage, or Discomfort Caused by

5. Insects
6. Diseases, parasites, and nematodes
7. Weeds
8. Fire and other hazards

Efficient Production and Quality Improvement

9. Biology of plants and animals
10. Improving biological efficiency of plants & animals
11. Increasing consumer acceptability of farm and forest products
12. Mechanization and improvement of physical efficiency
13. Management of labor, capital, and other inputs to maximize income

Product Development and Processing

14. Chemical and physical properties of food products
15. Developing new and improved food products & processes
16. Chemical and physical properties of non-food products
17. Developing new and improved non-food products and processes.

B. COMMODITY OF RESOURCES

Natural Resources

1. Soil and land
2. Water
3. Watersheds and river basins
4. Air and climate
5. Recreational resources
6. Timber and forest products
7. Range
8. Wildlife and fish

Crops and Crop Products

9. Citrus and subtropical fruit
10. Deciduous and small fruits and tree nuts
11. Potatoes
12. Vegetables
13. Ornamentals and turf
14. Corn
15. Grain sorghum
16. Rice
17. Wheat
18. Other small grains
19. Pasture
20. Forage crops
21. Cotton
22. Cottonseed
23. Soybeans
24. Peanuts
25. Other oilseed crops
26. Tobacco
27. Sugar crops
28. Miscellaneous & new crops

Animals and Animal Products

29. Poultry
30. Beef cattle
31. Dairy cattle
32. Swine
33. Sheep and wool
34. Other animals
35. Bees and honey

Manmade Resources Used on Farms or by People

36. General purpose farm supplies and facilities, including equipment, structures, fertilizers, and pesticides
37. Clothing and textiles

C. FIELD OF SCIENCE

Biological

1. Biochemistry and Biophysics
2. Biology—Environmental, Systematic, and Applied (Botany, Ecology, Zoology, etc.)
3. Biology—Molecular
4. Entomology
5. Genetics
6. Immunology
7. Microbiology
8. Nematology
9. Nutrition and Metabolism
10. Parasitology
11. Pathology
12. Pharmacology
13. Physiology
14. Virology

Physics

15. Chemistry—Analytical
16. Chemistry—Inorganic
17. Chemistry—Organic
18. Chemistry—Physical
19. Engineering
20. Geology and Geography
21. Hydrology
22. Mathematics and Statistics

Table 11.1 --*Continued*

A. ACTIVITY	B. COMMODITY OF RESOURCES	C. FIELD OF SCIENCE
Efficient Marketing, Including Pricing and Quality	38. Food	23. Meteorology
18. Identification, measurement & maintenance of quality	39. Housing, household equipment & non-textile furnishings	24. Physics
19. Improving economic & physical efficiency in marketing, including analysis of market structure and functions	*Human Resources, Organizations, and Institutions*	*Social and Behavioral*
20. Analysis of supply, demand and price, including interregional competition	40. People as individual workers, consumers, and members of society	25. Anthropology
21. Developing domestic markets, including consumer preference and behavior	41. The family and its members	26. Economics
22. Foreign trade, market development, and competition	42. The farm as a business enterprise	27. Education and Communications
Improvement of Human Nutrition and Consumer Satisfaction	43. Communities, areas, and regions, including counties and States and their institutions and organizations	28. History
23. Nutritional values, consumption patterns, and eating quality of foods	44. Agricultural economy of United States & sectors thereof, including interrelationships with the total economy	29. Law
24. Quality of family living, including management and use of time, money, and other resources	45. Agricultural economy of foreign countries and sectors thereof, including interrelationships with the total economy.	30. Political Science
Development of Human Resources and of Economies of Communities, Areas, and Nations	46. Farmer cooperatives	31. Psychology
25. Description, inventory, and trends	47. Other marketing, processing, and farm supply firms	32. Sociology
26. Economic development and adjustment	48. Marketing systems and sectors thereof	
27. Improvement of social well being, including social services and facilities and adjustment to social and economic changes	49. Research which cannot be allocated to one or more of the above commodities of resources	
28. Evaluation of public programs, policies & services		
29. Research which cannot be allocated to one or more of the above activities		

Source: U.S. Department of Agriculture and Association of State Universities and Land Grant Colleges, *A National Program of Research for Agriculture* (Washington, D.C.: U.S. Government Printing Office, 1966), p. 26.

placed on meeting national food needs. In many developed countries with relatively small but politically articulate agricultural constituencies, discussion of research benefits tends to emphasize the gains to agricultural producers. The contribution of agricultural research to foreign exchange earnings does not go unnoticed when a minister of agriculture discusses budget issues with a minister of finance or a director of the budget.

In spite of these differences in rhetoric, however, research administrators generally are very uneasy about attempts to implement "demand-oriented" research programs, that is, to direct research efforts toward specific social or economic objectives. They are much more comfortable with a "supply orientation," that is, with research efforts that attempt to take advantage of perceived opportunities for scientific or technical advance. This orientation toward the supply, or opportunity, side of the equation rather than toward the demand, or value, side, in my judgment, has often led to a lack of effectiveness on the part of research administrators in dealing with budget offices, legislative committees, and special-interest groups. There are an infinite number of interesting scientific problems, but not all of them are important. The effective research administrator must be able to resolve the interests of scientists in exploring the endless frontier of interesting problems with the legislative demands that funds be allocated to those areas that are most important.

In the next four sections I give particular attention to the factors that determine the distribution of the gains, and the losses, from research and that influence the incentives to support research.

Gains to producers and consumers in a closed eocnomy

In a closed economy in which exports and imports are limited, it is fairly easy to sort out the gains to producers and consumers from agricultural research that enhances productivity growth. Initial gains from lower unit production costs are realized by farmers who first adopt the new technology. As the new technology is diffused and production increases, a larger and larger portion of the unit-cost reduction will be shared with consumers.

When the rate of growth in productivity (measured in terms of output per unit of total input or the rate of decline in unit costs) is less than the rate of growth in demand (from population and income growth), prices rise, but less rapidly than if there were no technical change. Although the consumers gain from less-rapid price increases, most of the gains are realized by producers. When the rate of growth in productivity is slightly more rapid than the growth of demand, prices decline and the gains from lower costs are shared by producers and consumers.

When the rate of growth in productivity is substantially more rapid than the rate of growth in demand, all of the gains from productivity growth may be transferred from producers to consumers in the form of lower prices. Thus, the share of the productivity growth retained by producers declines and the share transferred to consumers increases as the rate of productivity growth rises relative to the rate of growth in demand. The rate of transfer of productivity gains to consumers, in the form of lower prices, also is greater when consumer demand is unresponsive (that is, inelastic) with respect to price.

In a closed economy, when the primary objective of research investment is to assist consumers, research effort should be directed to commodities for which demand is relatively unresponsive to changes in income and prices. These are poor people's foods—basic carbohydrates, such as cassava, maize, rice, and wheat, and vegetable proteins, such as beans. If the primary objective is to improve the income of farmers, research should be directed toward commodities for which demand is responsive to income growth and price changes. These are the products consumed by the middle classes and the rich—animal proteins and commodities that add diversity and interest to the diet, such as vegetables and fruits, or that are associated with other forms of conspicuous consumption, such as ornamental horticultural crops and animals used for sport and recreation.

Gains to producers and consumers in an open economy

In an open economy, a larger share of the gains from research leading to unit cost reduction or productivity growth is captured by producers than in a closed economy. The extent to which the gains are retained by producers depends, in addition to domestic demand elasticities, on the amount of a particular commodity that a country exports relative to the size of the world market. When exports are small, a rise in productivity can permit expansion of exports without having a noticeable effect on the world price. In this case, essentially all of the gains are retained for the producers. When the country accounts for a significant share of the world exports of a commodity, expansion of exports can be expected to cause prices to fall, just as in a closed economy. In this case, the gains are shared with foreign as well as domestic consumers. Producers of competing products in other countries that do not experience comparable productivity growth lose.

The effect of productivity growth on producers and consumers of a commodity that is partially produced at home and partially imported is somewhat different than in the case of a commodity that is exported. When productivity growth enables the country to expand domestic production and partially eliminate imports, most of the gains are realized by producers. When the productivity gains are sufficient to enable the country to make the transition from importer to exporter, domestic consumers may realize substantial gains. Although the country is an importer, prices are typically somewhat above world market prices as a result of shipping and related costs. When the country becomes an exporter, prices typically decline to below the world market price in order to absorb shipping costs to the new export markets. Unless exports expand rapidly, producers may not realize sufficient gains to offset the price reduction resulting from the transition. All of the gains, and perhaps some of the losses to producers, are realized by domestic consumers.

If the objective of research is to increase income to producers, research should be committed first to those commodities that are currently exported and second to those commodities on which research would enable the country to achieve a substantial export market. If the objective is to transfer the gains to consumers, research should be focused on commodities in which the country imports a small share of its consumption. A small increase in production, relative to consumption, in this situation, will result in a transition to a net export position, or at least to a potential export position, and push domestic prices below world market prices.

Saving land, saving labor, and saving energy

The allocation of resources to research also involves choices about the importance of releasing the constraints imposed by resource suppliies—of saving land and labor, for example. These choices are implicit in decisions about expanding or contracting research on problems such as soil and water conservation, soil fertility, photosynthetic efficiency, mechanization, energy use, and labor efficiency and management. What criteria are available to determine the relative balance between agricultural research directed primarily toward decreasing labor requirements per hectare or research directed toward increasing the amount of product that can be produced per hectare?

Historically, the answer to this question has been quite clear. In countries such as the United States, Canada, and Brazil that had relatively abundant land resources and a strong demand for labor in industry, the primary thrust was toward improvements in mechanical technology that would enhance labor productivity. Only after expansion of the area available for cultivation became limited was attention turned to the development of technologies to expand output per hectare. The mechanical revolution in American agriculture began in the middle of the 19th century. The biological and chemical revolution did not begin until after the first quarter of the 20th century.

In countries such as Japan and Denmark that had abundant labor and relatively limited or poor land resources, the primary thrust in agricultural technology was toward increased output per hectare. In Japan, the emphasis was placed on increases in crop yields. In Denmark, the emphasis was placed on increased crop yields per hectare and on technologies that facilitate intensification in the production of livestock and livestock products. In both countries, research designed to enhance labor productivity was delayed until the agricultural labor force began to decline in response to the rising demand for labor in the nonagricultural sectors of the economy.

In addition to the changing relative prices of land and labor, declining real prices of energy gave a further impetus to the invention of technologies that permitted the substitution of mineral fuels for organic sources of energy: tractors that utilized petroleum-based fuels were substituted for animal power that utilized farm-produced feed. The declining price of energy, embodied in chemical fertilizers, encouraged the development of crop varieties capable of responding to higher levels of nutrition.

Since the early 1970s, the world has entered into a period of great uncertainty with respect to changes in the relative prices of labor, land, and energy. The end of the era of cheap energy, like the end of the era of cheap land, is inducing a reallocation of research efforts. But the new sources of productivity growth have not yet been clearly identified. Until the new trends become more evident than they have been during the 1970s, the appropriate allocation of research effort among land-, labor-, and energy-saving alternatives will remain uncertain. In this environment of great uncertainty, an efficient research portfolio will include a wide range of options. It should avoid becoming locked into a commitment, or a "fix," on any single option. It is, for example, too early to be able to make firm judgments about the proportion of nitrogen supply that can be expected from advances in biological nitrogen fixation, low-pressure nitrogen systems, and/or improvements in the efficiency of conventional high-pressure nitrogen technology. As long as this uncertainty remains, resources should be allocated to the exploration of the possibilities for each of the several potential options.

Research for large farms and small farms

During the 1960s and 1970s, agricultural research institutions in both developed and developing countries have been widely criticized for focusing their research efforts on the problems of large farms and for neglecting research that would be beneficial to small farmers. Research designed to improve labor productivity has been criticized on the grounds that it leads to displacement of workers by machines. An attempt has been made in the state of California to legislate restrictions on mechanization research at the University of California.

Some of this criticism is valid. Some of it is ideologically motivated. Much of it is confused. The long-term thrust of research and development on mechanical technology in American agriculture is a response to the rising real price of labor. It has been primarily a response to a labor shortage rather than a source of labor displacement. But this does not mean that the concern with premature mechanization may not be valid in specific situations. Subsidies to mechanization have occurred in several forms. In the United States, tax laws that provide for investment tax credits and accelerated depreciation schedules have driven a wedge between private profitability and economic efficiency. In Brazil and India, access to foreign exchange on excessively favorable terms has at times biased the choice of technology in favor of mechanization and often in favor of large-scale rather than smaller, intermediate-scale equipment.[6] When the choice of technology is subsidized in this manner, it has the effect of inducing related research, in fields such as agronomy and farm management, designed to improve the efficiency and to speed the diffusion of a technology that is itself not appropriate.

But this is only part of the issue of technology for small farms. Is it possible to design technologies that are specifically suited to the needs or the factor endowments of small farms? I find it very difficult to think of examples of technology that would have greater benefits—that is, result in greater unit cost savings—for small farms than for large farms. But it is not too difficult to think of technologies that are roughly neutral in their impact. Indeed, much of the yield-increasing biological and chemical technology is roughly neutral with respect to size. The effect of a new pesticide on a yield of rice may be no different when the pesticide is applied by aerial sprayers than when it is applied by backpack sprayers. The choice of application technology in this case would depend on the price of labor relative to the price of capital equipment.

There is, however, one way in which research benefits may be biased in favor of small farms in some cases. That is in the choice of commodity emphasis. In many countries in Latin America, beans are produced on small farms and beef is produced on large farms. A decision to improve the productivity of bean production does, therefore, have the effect of biasing the direct impact of gains from productivity growth in favor of small farms. Similarly, a decision to conduct research on beef does bias the direct impact in favor of large producers.

A choice in favor of beans relative to beef also directs the gains that get transferred ~~to consumers~~ to low-income consumers, many of whom are small farmers or hired laborers. How much of the gains from productivity growth will be retained by the farmers who initially adopt the new technology will depend on the relationship between growth of productivity and growth of demand, which was outlined in the sections on closed and open economies.

ALLOCATION OF RESOURCES IN RESEARCH

In the introduction to this chapter, it was noted that there are two distinct stages involved in research resource allocation or investment strategies. One stage involves an initial preordering of research programs based on some judgment of the potential value of the research. This decision may be made during the process of allocating resources to the research system or to the individiual research institute or station. A second stage involves the selection of individual research projects that can advance the work of the preselected program most effectively. This second stage always involves explicitly or implicitly a consideration of cost-benefit and cost-effectiveness criteria. This does not mean that these are the only criteria that are involved in project selection. A research director may, for example, continue to support a modest level of research activity by a relatively unproductive staff member in order to get some return, however modest, from the fixed costs of salary and related benefits.

In a small research institution with a highly personal style of management, allocation decisions may be made in conferences with the individual staff members or in committee meetings with research teams. Project documentation may serve primarily as confirmations of decisions rather than as an imput to the decision-making process. This procedure may be highly effective in a research organization in which the director has the professional background and the intellectual capacity to engage in effective dialogue with the individual researchers or research teams about the methodology and significance of the research effort.

In larger research organizations, using this personal management style is not feasible. Even if using it were feasible at the individual research laboratory, institute, or station level, it would not solve the problem of communication with the higher decision-making levels of a state or national research system. During the 1960s and the 1970s, a great deal of effort was devoted to the development of more-formal systems for the ordering of the information needed for research decision making. Walter L. Fishel has pointed out that these decision information systems "typically have two primary functions: filtration and condensation." Filtration is concerned with separating the relevant from the irrelevant. Condensation is concerned with the reduction of relevant data through analysis or other useful information techniques to the most meaningful form for the research administrator.

In the next section, I present a partial inventory and an assessment of the several formal approaches that have been developed for research planning. The approaches are grouped under scoring models, experimental approaches, and benefit-cost methods.

Scoring models

The earliest and most widely used models involve the scoring or ranking of research areas or projects by panels.[7] The panels may consist of peers, and they may also involve administrators and users. Two scoring models that have been employed in the United States at the state or federal level are described in this section.

The National Program Study. The preparation of *A National Program of Research for Agriculture* by the National Association of State Universities and Land Grant Colleges and the U.S. Department of Agriculture in 1965 and 1966 involved an exceptionally ambitious attempt to utilize scoring methods in the planning of agricultural research. The task force set up to conduct the study was charged with evaluating the strengths and weaknesses of the federal-state research program, with identifying future research priorities, and with recommending the levels of support and manpower required for agricultural research over the following 10 years.

The first step in the study involved the development of the three-way classification system that is now used in the computer-based Current Research Information System (CRIS) for the storage and retrieval of research reports. (See table 11.1.) This system was then used to inventory the financial support and scientist-years devoted to research by the categories in the classification system.

Future research needs were estimated by ranking each of 91 research objectives, or goals, by the 8 criteria listed in table 11.2. Scores were obtained by having panels in each of the commodity or resource areas rate each problem from 1 to 5 according to how well it satisfied each of the 8 criteria and then multiplying the ratings by the weights listed in the table. The scores were then used to project the socially desirable number of scientist-years for each problem area for 1977. The results of this exercise, aggregated into 9 general research goals, are shown in figure 4.1L p80.

Table 11.2. Criteria and Weights Used for Establishing Relative Program Projections in the *National Program of Research for Agricultural Study*

Criterion	Weight
Extent to which the research meets state experiment station, department, and national goals	9
Scope and size considering area, people, and units affected	8
Benefits of research in relation to costs	7
Urgency of research	10
Contribution to knowledge	9
Feasibility of implementation and likelihood of successful completion in a reasonable period of time	5
Likelihood that the research results will be available elsewhere	6
Likelihood of extensive and immediate adoption of results	6
	60

Source: U.S. Department of Agriculture and Association of State Universities and Land Grant Colleges, *A National Program of Research for Agriculture* (Washington, D.C.: U.S. Government Printing Office, 1966), p. 29.

The methodology employed in the national program was conceptually simple but operationally complex. Several participants have indicated that they regarded the use of the scoring method as among the least valid aspects of the planning effort.

The North Carolina model. In 1972 the North Carolina Agricultural Experiment Station initiated a very intensive review of its research program. The immediate goal was to determine the relative emphasis that the North Carolina station should give to the research problem areas identified in the *National Program*.

A joint administration-faculty effort was mounted to conduct an exhaustive review of all the research programs and projects at the station and to explore possible redirections for the future. Twenty task forces, each composed of 5 to 10 research and extension faculty members and, in some cases, state agency personnel, reviewed the station's entire program. These committees recommended quantitative changes in research support and scientific effort. Each recommendation was ranked according to prespecified scoring criteria. Following the completion of the task forces' reports, 18 extramural panels consisting of scientists from other universities and the Cooperative Research Service (USDA) evaluated and rated the task forces' recommendations. The 23 academic departments at North Carolina State University were then asked to evaluate the task forces' and extramural panels' reviews from a disciplinary perspective and also to rank the task forces' recommendations.

The scoring models used in the North Carolina study were based on a revision of the criteria and weights used in the *National Program* study. Separate criteria and weights were developed for each of four major research areas. The initial revisions were developed by the experiment station's administration. They were submitted by mail to members of the Research Planning Advisory Committee to obtain suggestions for revisions of the criteria sets and weights. Revisions, weights and explanations were developed by each member of the committee, were summarized by the administration, and were reevaluated along an interactive Delphi procedure format.[8] This procedure was repeated twice. The four criteria sets and weights developed in this way are listed in table 11.3.

Each member of the three groups—the task forces, the extramural panels, and the department heads—then independently scored the task forces' recommendations for changes in research problem area resources on a five-point scale without knowing the weight attached to each criterion. Project rankings were then obtained from the scores by using two standards: the average score by all raters and the average score of all raters minus one standard deviation.

The purpose of the latter method was to lower the rank order of research problem areas having the greatest degree of variability among the scores by individual participants. It turned out that there were considerable differences among raters and among groups of raters. The rank-order correlation between department heads' scores and extramural panels' scores was only 0.45. The correlation between the task forces' and the extramural panels' rankings was 0.42 and between the task forces' and the department heads' rankings only 0.24. Furthermore, an analysis of variance suggested that the variations among the groups' scores were not significantly different than the variations among individuals in the same group.

A perspective on the use of scoring methods. The two cases described in this section cannot, of course, fully represent the large

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Table 11.3. Criteria for Evaluating Research Problem Areas at the North Carolina Agricultural Experiment Station

Research Area	Criterion	Criterion Weight
A. Biological sciences and technology	1. Urgency—basic information needed to aid in solution to threat or problem.	20
	2. Cost relevance—expected long-term benefits in relation	15
	3. Degree to which similar research is not now being conducted or not likely to be conducted elsewhere (higher scores if inadequate research results expected elsewhere).	15
	4. General importance and potential for contribution to knowledge. Higher scores to be assigned for greater scientific merit and potential for contribution to faculty development and improved academic performance.	50
	Total	100
B. Animals and plants	1. Extent to which proposed research is consistent with station, regional, and national goals in agriculture and forestry. Consider economic value of the crop or animal enterprise and its products to people of North Carolina.	35
	2. Cost relevance—expected benefits in relation to costs.	20
	3. Extent to which similar research of adequate quality is not being conducted on this commodity elsewhere (higher score for RPAs and sub-RPAs for which adequate results are not likely to be available elsewhere), and degree of urgency of need for research results.	20
	4. Potential for contribution to knowledge.	25
	Total	100
C. Environment and natural resources	1. Extent to which proposed research is consistent with station, regional, and national goals in natural resource development and conservation.	35
	2. Cost relevance—expected benefits in relation to costs.	15
	3. Extent to which similar research of adequate quality on this resource is not being conducted elsewhere (higher scores for inadequate research elsewhere) and whether or not there is (1) a threat to natural resource, (2) public pressure, or (3) a critical need for environmental protection.	15
	4. Potential for contribution to knowledge.	20
	5. Extent to which the research will aid in meeting broader public service commitment of the school and university, beyond traditional statutory charge of the experiment station.	15
	Total	100
D. Food-Fiber-people-economics	1. Extent to which recommended research is consistent with station, regional, and national goals of promoting and protecting public health and improving family	

Table 11.3.—*Continued*

Research Area	Criterion	Criterion Weight
	living; potential for improving quality of life and developing rural communities in North Carolina.	35
	2. Cost relevance—expected benefits in relation to increased costs of research in these areas, resulting from these recommendations.	20
	3. Extent to which similar research of adequate quality is not being conducted elsewhere (higher scores for inadequate research elsewhere) and whether there is (1) public support for research to evaluate the impact of improved agricultural technology, (2) a threat to public health, or (3) a need for information to support new processing industries	20
	4. Potential for contribution to knowledge	25
	Total	100

Source: C. Richard Shumway, "Models and Methods Used to Allocate Resources in Agricultural Research: A Critical Review," in *Resource Allocation and Productivity in National and International Agricultural Research*, Thomas M. Arndt, Dana G. Dalrymple, and Vernon W. Ruttan, eds. (Minneapolis: University of Minnesota Press, 1977), p. 443.

number of research evaluation and planning efforts that have made use of scoring methods. Others have been reviewed in the papers by Shumway and by Norton and Davis referred to at the beginning of this section. The two cases do, however, serve to illustrate some of the weaknesses of the scoring method approach. And they also serve to suggest occasions when the use of scoring methods may be appropriate.

One of the serious problems with scoring approaches has been the difficulty of getting the participants to play by the rules. This problem was regarded as a particularly serious one by some of the participants in the *National Program* study. In the North Carolina state study, many participants simply refused to rank some of the research problem areas. Many Delphi studies experience a high "dropout" rate—panelists simply tire of the effort before the last iteration is completed.

A more serious problem with scoring approaches has been the difficulty of designing a reasonably independent and relevant set of criteria or objectives. Considerable progress in this direction was made between the list employed in the *National Program* (table 11.2) and the list employed in the North Carolina state study (table 11.3). But problems remain. How independent, for example, are such criteria as: "extent to which proposed research is consistent with station, regional, and national goals"; and "cost relevance—expected benefits in relation to costs"?

The most serious problems emerge when an attempt is made to combine individual project weights with criterion or objective weights to arrive at a global allocation of research resources at the state or national level. The aggregation of scores is loaded with booby traps. The rules adopted for calculating scores tend to be arbitrary and the shadow prices that are implicit in the weights that emerge from the aggregation process often bear little relationship to the relative weights that would be cast up by market processes or to the shadow prices that might be generated by a rigorous application of the constrictions of utility theory.

But scoring methods can be very useful when employed at a less aggregate level. They are probably most useful when employed in the scoring of individual projects against a single criterion, such as scientific or economic significance. the USDA's competitive research program, which is designed to support basic research in each of four areas—(1) biological nitrogen fixation, (2) photosynthesis, (3) genetic mechanisms for crop improvement, and (4) biological stress in crop plants—represents a useful example. A simple ranking of the projects submitted in each area by a panel of knowledgeable scientists can probably be conducted without too much bias. But the initial selection of the four priority areas and the specification of the priority that each should receive in the allocation of financial and scientific effort appear to be a task for which scoring methods are poorly suited.

Experimental approaches

Methods of identifying research priorities have been developed that are based directly on the modeling of physical and biological relationships and that incorporate parameters drawn from the analysis of experimental results and field investigations. These experimental approaches to the establishment of research priorities have typically placed greater emphasis on the value of removing constraints on performance or genetic improvement at the level of the individual field or plot, or even the individual plant or animal, than on the scoring methods discussed above. In this section I examine three such methods: yield constraint models, selection indexes, and plant growth models.

Yield constraint models. Attempts have been made at both the International Center for Tropical Agriculture (CIAT) in Colombia and at the International Rice Research Institute (IRRI) to conduct farm-level investigations by joint agroeconomic research teams in order to obtain data on crop production constraints.[9] In some cases, these farm-level observations have been supplemented by experiments designed to confirm or to refine the measures obtained from the farm-level observations. Analytical methods range from yield response and partial budgeting to relatively sophisticated crop loss or crop production systems models.

The single-commodity approach typically involves two stages. The first is an agroeconomic observation in farmers' fields that describes the production process, identifies factors that limit production and productivity, and attempts to estimate their relative importance. Data are sought on agrobiological factors (cropping systems, cultural practices, soil quality, plant type, pathogens, and others), on economic factors (use and prices of inputs, gross and net revenues), and on institutional factors (credit, tenure, and others). The second step involves the use of agrobiological experiments to provide more accurate measures, for example, of the yield-depressing effects of a soil problem.

The multicommodity, or farm-level, approach involves, in addition, more complex cropping systems trials or experiments that explore interaction effects between, for example, crop varieties and cropping practices. The CIAT has employed a systems engineering methodology in order to analyze the dynamic response of small-farm systems as a function of input and output relationships with the biological, ecological, and institutional environment. The CIAT model also included links to sector-level demand and supply relationships, thus permitting the analysis of aggregate output, productivity, and distributional impacts. The more complex farming systems' simulation efforts at this time can be viewed more as pilot efforts than as operational planning instruments.

Selection indexes. Animal geneticists have used weighting methods to construct composite measures, termed selection indexes, since the mid-1940s. The selection indexes are used to evaluate the incremental contribution of the several traits that enter into breeding programs to the economic value of alternative selection strategies.[10]

The problem that led to the development of selection indexes is that the traits that are influenced by a breeding effort are usually not independent of each other. Important traits are often negatively correlated. Furthermore, genetic traits are discovered by a stochastic search process, and there is a high degree of uncertainty in the transmission of traits to offspring. In breeding decisions, therefore, the breeder is confronted with great uncertainty in attempting to make trade-offs among traits.

The initial selection indexes were constructed by a linear weighting of the traits affected by the breeding program according to the economic value of each trait. In the more sophisticated variants, the index was constructed to reflect (1) the variance and covariance of the measured expression of the trait (phenotypic value), (2) the variance and covariance of the increment in the measured expression of the trait judged by the improvement in the progeny over the expected population value (the breeding value), and (3) the economic value of the trait. Because cost differences were often not fully considered, breeding indexes are more appropriately viewed as partial rather than as total productivity measures.

Recently, there have been a number of efforts to integrate increasingly sophisticated genetic and economic models. The selection process involves a search for the extreme values of specific traits. It also involves the use of quantitative information on genetic and genetic-environmental interactions. The economic value of the traits depends on input and product market price relationships and on the technical relationships linking inputs and output.

Plant growth models. The development of plant growth models has been an expanding area of research since the development of canopy photosynthesis models.[11] These models involve the application of biophysical principles to crop growth and the construction of computer models to simulate growth processes.

One of the more successful of these efforts has been a model (SIMCOT II) that simulates the growth of the cotton plant from emergence to maturity. The effort began in 1968 with attempts to model respiration and flowering. Considerable effort was made to reinterpret earlier experimental data within the modeling framework. By the early 1970s, the work had progressed to the modeling of the supply and use of nitrogen and water. By 1973, efforts were being directed to the modeling of the interaction between insect pests and the cotton plant. By the late 1970s, efforts had progressed to the point where a boll weevil-eradication model could be attempted.

The potential for the use of plant growth models for research design and planning is very promising. The modeling efforts offer the possibility of making more precise identifications of the constraints on crop production. When the results are combined with economic data, the value of removing growth or yield constraints can be estimated. At the present stage of development, it is still necessary to build a great many ad hoc assumptions into such models. It remains difficult to make accurate probability statements about the properties of the models.

A perspective on the use of experimental approaches. The experimental approach, particularly crop loss and plant growth modeling variants, is experiencing rapid methodological development. An important objective of this effort is to provide empirical information on the results of research designed to relax constraints, to improve particular traits, to shift response relationships or to achieve other objectives of applied research efforts. Because these investigations can be conducted as part of a research program, rather than as a diversion from research, the results can be fed directly back into the redesign of research effort at the individual research program level. The information generated from the experimental approaches can also be cast in a form that is useful to research-planning and budget offices.

Benefit-cost methods

The benefit-cost information systems attempt to be more explicit than the scoring models with respect to the inputs into the research process, the outputs expected from the research, and the relationship between the cost streams and the benefit streams.[12] Information of the type generated by the experimental approaches is directly useful in benefit-cost as well as in other forms of impact evaluation.

The Minnesota agricultural research resource allocation and information system. A system for the collection and computer processing of information that could be used either for the subjective evaluation of research activities or for the formal estimation of projected cost-benefit measures was developed and tested by Walter L. Fishel at the University of Minnesota in 1970. The model, which he labeled MARRAIS, involved three major steps: specification, estimation, and analysis. (See figure 11.1.)

The model was designed to provide benefit-cost, benefits-minus-cost, and internal rate of return measures for research projects or programs. Knowledgeable scientists in the field of study related to the proposed research project were surveyed in order to obtain the information needed. The surveys provided estimates of the average annual expenditures, the time requirements, and the scientific and technical feasibility of the research effort. Subjective probability distributions of costs and values were generated for alternative levels of annual expenditures by a Monte Carlo sampling procedure.

MARRAIS is still, more than a decade after its development, clearly one of the most logically thought out and procedurally sophisticated

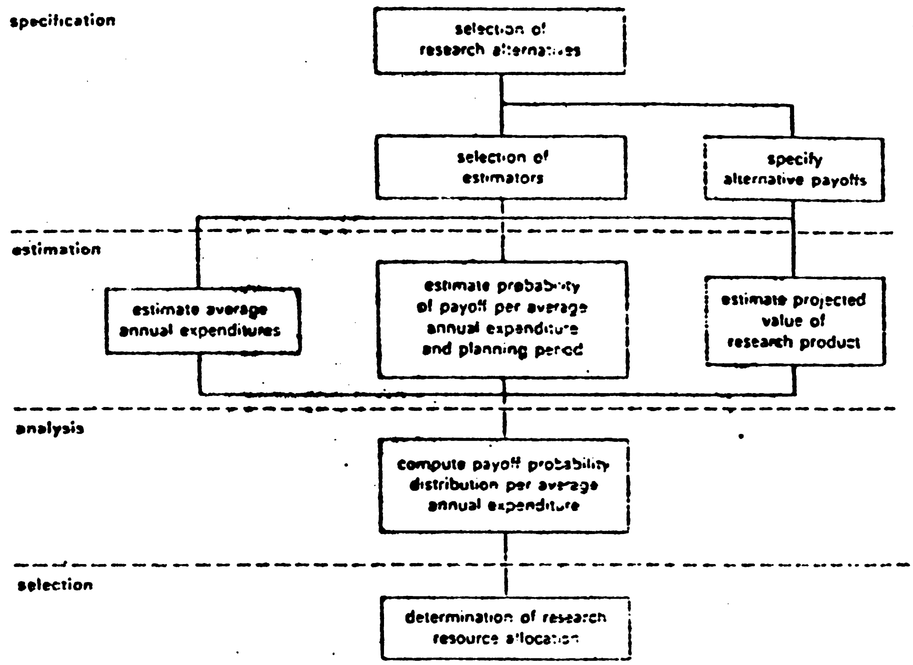

Figure 11.1. Modular Form of Cost-Benefit Estimation Model. (From Walter L. Fishel, "The Minnesota Agricultural Research Resource Allocation Information System and Experiment," in Walter L. Fishel, ed., *Resource Allocation in Agricultural Research* [Minneapolis: University of Minnesota Press, 1971], p. 354.)

research-planning models available. Its high cost to users has been an obstacle to its routine application.

Simplified benefit-cost models. In 1977 William Easter and George Norton developed a simplified MARRAIS-type model to analyze the U.S. land-grant universities' national budget requests for soybean and corn production research. Benefit-cost ratios were calculated from the lower range of estimates provided by scientists on the yield and cost effects of each research line and on the expected adoption rates for the new technology.

An important aspect of the analysis was the sensitivity of the benefit-cost ratios to variations in the probabilities of success, the expected yield increases, the product prices, and the length of the lags between research expenditures and the variability of the results to the farmers. Distributional effects were examined. These included the impact on prices of fats and oils, on meat prices, and on gross farm income. Aggregate gains to consumers and producers resulting from the proposed research were also projected.

A simplified cost-benefit analysis was also used by A. A. Araji, J. R. Sim, and R. L. Gardner to evaluate research and extension programs for several commodities in the western region of the United States and for pest-management programs in several regions of the United States. They also estimated the reduction in productivity that would result from eliminating maintenance research.

A perspective on the use of benefit-cost methods. A major limitation of the more technically sophisticated cost-benefit methods, such as MARRAIS, is that the costs involved in estimation, data storage and maintenance, and economic analysis can easily be underestimated by several magnitudes. A major advantage of even the simpler benefit-cost approaches is that they provide a consistent metric for relating the value of the resources used in research to the benefits that flow from research. The benefit-cost projections can, however, be no better than the judgments about research costs, the probability of research success, and the estimates of research benefits that are generated by the scoring methods or the estimates generated by the experimental approaches on which they are based. This is true regardless of the sophistication of the methodology used to derive the benefit-cost estimates.

LINKING PROJECT SELECTION TO RESEARCH RESOURCE ALLOCATION OBJECTIVES

I have employed, in the last two sections, the convention of focusing first on the considerations involved in the allocation of public research resources to achieve multiple objectives (the objective function) and then on the methods that are available to research administrators and planners to establish priorities among research projects and programs. The problem that remains unresolved is how to link these two bodies of analyses.

There are no fully developed methodologies that are capable of a simultaneous solution to this problem. Several methods have been employed in attempts to achieve convergence. The next section provides a perspective on three of these methods. All three methods represent a variation of growth accounting.

Consistency models

Perhaps the simplest of the several approaches involves a continuous monitoring of the sources of output growth. An example of this approach is an attempt that I made in the mid-1950s to evaluate the implications of projections of resource investment requirements that had been made by the U.S. Department of Agriculture, the President's Water Resources Policy Commission Report, and the President's Materials Policy Commission Report.[13] These reports were concerned with the question of the capacity of American agriculture to meet future food and fiber requirements. The emphasis of the studies was on "the transitory nature of present food surpluses." The Water Resources Policy Commission Report suggested, for example, that the equivalent of 100 million acres of cropland might have to be brought into production to meet 1975 agricultural production requirements.

The approach employed in assessing these projections utilized an equation of the Cobb-Douglas type (linear in logarithms) with a shift factor that captured the effect of productivity growth to examine the consistency between the projected output requirements and the alternative rates of growth of inputs and productivity. Four basic models, with annual rates of productivity growth ranging from zero to 2.4 percent per year were calculated. The several projections, along with the actual changes in output, inputs, and productivity, are presented in table 11.4. The projections implied that continuation of historical rates of productivity growth could be consistent with even a modest decline in land inputs. The realized rate of productivity growth was quite similar to the most rapid rate projected. The input mix projections, under very rapid technical progress, substantially underestimated the rate of decline in labor inputs and the rate of increase in current inputs.

A similar consistency model has been used by G. Edward Schuh to evaluate the 1972 Brazilian agricultural plan.[14] The results indicated that it would not be possible to meet the very high output growth rates projected in the plan within the constraints imposed by the anticipated growth of resource inputs and total productivity growth.

The consistency models have an advantage over models based on partial productivity projections such as land productivity (yield per hectare) or labor productivity (output per worker) in that they force the planners to face up to the problems of resource substitution in selecting the program activities designed to influence the rate of productivity and output growth. The major weakness of the simple consistency models of the type outlined above is that they do not incorporate direct links between research investment and technical change or between technical change in resource substitution and productivity growth.

Table 11.4. Alternative Projections and Realized Farm Output and Factor Input Indexes for 1960 and 1975 (1950 = 100)

		Zero Technical Progress[a]		Slow Technical Progress[b]		Rapid Technical Progress[c]		Very Rapid Technical Progress[d]		
		Low Land Inputs (I)	High Land Inputs (II)	Low Land Inputs (III)	High Land Inputs (IV)	Low Land Inputs (V)	High Land Inputs (VI)	Low Land Inputs (VII)	High Land Inputs (VIII)	Realized Technical Progress[f]
1960 Projections Inputs:										
Labor		88	88	88	88	78	78	78	78	65
Land		96	104	96	104	96	104	96	104	90
Capital[e]	(A)	178	172	140	136	149	143	124	121	114
	(B)	183	177	145	140	153	147	127	124	
Current[e]	(A)	214	207	169	163	178	172	148	145	170
	(B)	204	198	161	155	171	164	141	138	
Contributions to Output from:										
Inputs		122	122	112	112	110	110	100	100	96
Technological change		0	0	10	10	12	12	22	22	24
Total output		122	122	122	122	122	122	122	122	118
1975 Projection Inputs:										
Labor		81	81	81	81	67	67	67	67	30
Land		90	110	90	110	90	110	90	110	96
Capital[e]	(A)	346	318	199	169	218	201	132	122	133
	(B)	378	348	218	185	233	219	144	133	
Current[e]	(A)	547	505	317	240	346	318	210	193	472
	(B)	491	441	285	234	311	277	189	189	
Contributions to Output From:										

Table 11.4—*Continued*

	Zero Technical Progress[a]		Slow Technical Progress[b]		Rapid Technical Progress[c]		Very Rapid Technical Progress[d]		
	Low Land Inputs (I)	High Land Inputs (II)	Low Land Inputs (III)	High Land Inputs (IV)	Low Land Inputs (V)	High Land Inputs (VI)	Low Land Inputs (VII)	High Land Inputs (VIII)	Realized Technical Progress[f]
Inputs	160	160	135	135	129	129	100	100	96
Technological change	0	0	25	25	31	31	60	60	54
Total output	160	160	160	160	160	160	160	160	150

Source: Projections: Vernon W. Ruttan, "The Contribution of Technological Progress to Farm Output: 1950-1975," *Review of Economics and Statistics*, 37 (February 1956), pp. 61-69: Realized: Donald D. Durost and Evelyn T. Black, *Changes in Farm Production and Efficiency* (Washington, D.C.: U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, Statistical Bulletin No. 612, November 1978).

a. Increased inputs are assumed to account for the entire increase in output.

b. Technological change is assumed to occur at a sufficiently rapid rate to permit an increase in output per unit of input of 1.0 percent per year between 1950 and 1975. This is the 1910-1950 rate calculated on the basis of 1945-1948 prices and techniques.

c. Technological change is assumed to occur at a sufficiently rapid rate to permit an increase in output per unit of input of 1.23 percent per year between 1950 and 1975. This is the 1910-1950 rate calculated on the basis of 1910-1914 prices and techniques.

d. It is assumed that technological change occurs at a sufficiently rapid rate to account for the entire increase in output. This requires an increase in output per unit of input of 2.2 percent per year between 1950 and 1960 and 2.4 percent per year between 1950 and 1975.

e. Estimate A for capital and current inputs is based on the assumption that the ratio of capital to current inputs (C1/C2) will continue to decline at the same percentage rate as during the period 1910-1914 to 1945-1948. Estimate B is based on the assumption that the 1925-1927 to 1949-1950 rate will continue. See text for further discussion of estimates A and B.

f. Calculated for 1948-1953, 1958-1963, and 1973-1977. Capital indexes based on mechanical power and machinery; current inputs based on agricultural chemicals.

Sources of productivity growth models

In a recent report by the U.S. Department of Agriculture, Yao-chi Lu, Philip Cline, and Leroy Quance extended the consistency model approach to incorporate the effect of alternative levels of research investment on productivity growth and, more important, to assess the probable impact of specific technical advances on productivity growth.[15]

The first step in the Lu-Cline-Quance approach was to establish statistically the relationships between the effect of research and extension expenditures on the total productivity index. The effects of research and extension were separated from the short-run effects of weather and the longer-run effects of the level of education of the farm labor force. The statistical analyses permitted a careful identification of the average annual flow of benefits, and hence the impact of research and extension investment. The analysis implied that for the United States as a whole the benefit flow increases gradually for 6 or 7 years and then declines to a negligible level by the 14th year.[16] In a situation characterized by no real increase in the level of research expenditures (in which increases in public expenditures for agricultural research are offset by inflation) an annual increase in productivity of about 1 percent per year is projected. A real increase in research and extension funding of 3 percent per year would push the productivity growth rate to 1.1 percent per year.

The second step in the analysis was to consider the effect of several technological breakthroughs on productivity growth. An extensive literature review identified 12 areas in which technical breakthroughs, such as those that might be analyzed in a constraints model, might occur.[17] These areas were identified by using Delphi methods during interviews with research and extension workers in the Agricultural Research Service, the Cooperative State Research Service, and the Science and Education Administration.

Three areas were considered to have exceptional potential—photosynthesis enhancement and bioregulators in crop production and twinning in livestock production. Subjective probability distributions were constructed for the availability of each of the new technologies, and adoption profiles were developed for the diffusion of the new technologies. Estimates of research costs and productivity impact were made. A number of simulations were run to estimate the impact of the three technologies on the rate of productivity growth. The new technologies would not have a significant impact on production until the 1990s. A medium impact projection suggests that the new technologies could result in an increase in the projected rate of productivity growth from 1.1 to 1.3 percent per year for the period between 1975 and 2000 and an increase of 1.5 percent per year between 2000 and 2025. Even these rates are well below the rates achieved during recent years. (See table 10.1.)

The source of productivity growth approach is clearly an important advance over the older consistency approach. Its major limitation is, from some perspectives, that it involves an assessment of only the efficiency or productivity implications of the new technologies. The value of the approach is that it does provide some indication of the magnitude of the resource savings that could result from focusing a long-term research effort on a major area of research. The productivity measures could then be incorporated in models designed to measure the distributional effects of technical change, such as those discussed in the first section of this chapter.

Trade-off models

It seems clear that the interests of the public that provides the resources and of the legislative bodies that appropriate the funds to support agricultural research extend beyond the goal of efficiency in commodity production. Attempts have been made to develop models that are capable of evaluating the effects of research portfolio choice on a spectrum of variables often classified under such headings as equity and security, as well on the production, consumption, and growth criteria.

The Resource Allocation System for Agricultural Research (RASAR) developed by R. G. Russell in the United Kingdom is an example of a model of this type.[18] The ultimate goal of agricultural research was identified as having nine dimensions in three broad categories: *consumption*, including (1) quality, (2) quantity, and (3) availability; *security*, including (4) human safety, (5) economic defense, (6) food sources security, and (7) conservation; and *equity*, including (8) distribution, and (9) individual rights.

A mathematical programming model for assimilating the complexity of criteria and data into a form that could be used for decision making was developed. The individual units of analysis were research project units small enough to have a single primary objective and large enough to require significant amounts of time and money. Administrative constraints—such as financial and staff limitations, policy constraints such as urgency of the problem and social acceptance, and scientific and technical constraints stemming from the state of knowledge—were built into the model. The system outputs included: (1) *the research program*, the set of projects to receive support; (2) *support levels*, the level and role of support for each project; (3) *program utility*, which summarized the impact of the project on each dimension that entered in to the utility measure; and (4) *program sensitivity*, including a measure of the program's sensitivity to variations in program assessments, an indication of the projects that were barely included or excluded, an indication of whether reformation of a project would change its probability of being included, and an indication of how critical the weight assigned to each criterion is in the selection decision.

The model developed by Russell represents a very sophisticated attempt to link scientific judgments with respect to the opportunities to advance technology with both economic and noneconomic indicators of the value of the research output. Russell pointed out that even in this model a major issue remains unresolved. There is no way to combine the incommensurate measures in the goal dimensions to provide a project utility rating except to use an arbitrary weighting function!

THE LIMITS AND POTENTIAL OF RESEARCH PLANNING METHODOLOGIES

Where does this review of research resource allocation principles and methods lead with respect to decision making about research priorities and the allocation of research resources? How much effort can the director of a national research program, the director of an experiment station, or the leader of a commodity or resource research program afford to allocate to research on research management? These efforts tend to be in direct competition with research projects for resources. The general principle that resources devoted to management must add more to the efficiency of the system than the cost in terms of research projects not funded is difficult to apply in practice.

Clearly, the parity (or congruence) model that was outlined in the first pages of this chapter represents an inadequate response to society's concern about the value of new knowledge and new technology and to the science community's perception of the possibilities for advancing science and technology. But departures from the parity model should be based on informed judgment about the potential impact and value of scientific and technical effort. For example, does the low ratio of research expenditure to market value for soybeans reflect a judgment that advances in soybean productivity are hard to come by or a judgment about the value of soybeans to the American economy, or is it a result of bias in the system by which resources are allocated to research in the United States?

Increasingly powerful methodologies are becoming available to the directors of individual research programs, research institutes, and experiment stations for interpreting scientific, technical, and economic information in a manner that can increase the effectiveness of research effort, whether evaluated in terms of advances in knowledge or technology. In order to have access to these methodologies, resources must be allocated to interdisciplinary experimental design and system-modeling efforts such as those described in the sections on scoring methods, experimental approaches, and benefit-cost methods.

A major advantage of these methodologies is that they can be carried out as an integral part of a research program. Their results become directly available to individual scientists and research teams. Their results can be fed back immediately into research planning and design. They can also provide the information that is needed by research-planning units operating at the central level of a research organization.

But research policy and planning are not simple technical exercises that can be left in the hands of research scientists and managers! Judgments about the priority of public-sector support for agricultural research in relation to other demands for public resources must, in most countries, come out of an intricate bargaining process that goes on between national (or state or provincial) legislative bodies and executive agencies. Judgments about the relative emphasis that should be given to saving labor, saving land, and saving energy—as well as the priority that should be attached to research on the spillover effects of production technologies on the health and welfare of producers and consumers and the impact of agricultural technology on environmental amenities and on the structure of rural communities—must also come out of this same bargaining process.

The development and use of the research-planning and resource-allocation methodologies reviewed in this chapter should not, however, be viewed as being inconsistent with the legitimate role of political decision processes. The political dialogue leading to research resource allocation should be fully informed about the costs and benefits of research resource allocation decisions. Information on the historical and potential impact of technical change on productivity growth and on the distributional impact of technical change can represent a valuable input into these bargaining processes, even if it serves primarily to keep the debate reasonably honest. It is important to know whether utilization research gets used or whether hard tomatoes end up on the fresh vegetable counter or in catsup and pizza sauce. It is important that the self-interests of enthusiasts and promoters not be allowed to obscure the judgments of plant scientists, engineers, and economists about the *advances* in knowledge and technology that will have to be realized if biomass is to become a more efficient source of energy.

What is my final judgment on the methodologies for research resource allocation presented in this chapter? There can be little question that the judicious selection and application of the new methodologies that have been reviewed in this chapter could represent exceedingly powerful tools in the hands of a research director who insisted on making research resource allocation decisions and on understanding how and why he or she made them.[19] They could also be an embarrassment to a weak research director who hoped that research decisions would be revealed by applications of the planning methodologies that are available to his or her staff. These and related analytical methodologies represent potentially powerful aids in the decision-making process. But they can achieve effectiveness only in the hands of a research manager who has the intellectual vigor to grapple with both the substance of the research program and the tools that are available for research decision making.

Let me add one final cautionary note. The methods outlined in the chapter have assumed that the objective of agricultural research can be evaluated primarily in terms of the rate and direction of productivity growth and in terms of how the dividends from productivity growth are partitioned among different groups of producers and between producers and consumers. Over the last several decades, this presumption has been continually challenged. In the final chapter of this book, an attempt is made to consider some of the challenges to articulating and implementing a more comprehensive set of objectives for decision making in agricultural research.

NOTES

1. I am indebted to Jeff Davis, Bobby R. Eddleman, Walter L. Fishel, Robert W. Herdt, Yoav Kislev, George W. Ladd, Yao-chi Lu, Bryon E. Melton, George Norton, Joseph P. Percell, Richard Sauer, and Richard C. Schumway for their comments on and criticisms of an earlier draft of this chapter.

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2. These efforts have given rise to a substantial literature. Among the more useful items are the following: Walter L. Fishel, ed., *Resource Allocation in Agricultural Research* (Minneapolis: University of Minnesota Press, 1971); I. Arnon. *The Planning and Programming of*

Agricultural Research (Rome: FAO, 1975); Thomas M. Arndt, Dana G. Dalrymple, and Vernon W. Ruttan, eds., *Resource Allocation and Productivity in National and International Agricultural Research* (Minneapolis: University of Minnesota Press, 1977); W. B. Back, ed., *Technology Assessment: Proceedings of an ERS Workshop, April 20-22, 1976* (Washington, D.C.: National Economic Analysis Division, Economic Research Service, U.S. Department of Agriculture, AGERS-31, September 1977); George W. Norton, Walter L. Fishel, Arnold A. Paulsen, and W. Bert Sundquist, eds., *Evaluation of Agricultural Research* (St. Paul: University of Minnesota Agricultural Experiment Station, Miscellaneous Publication 8-1981, April 1981). For a useful review of this and related literature, see G. Edward Schuh and Hillo Tollini, "Costs and Benefits of Agricultural Research: State of the Art and Implications" (Washington, D.C.: Consultative Group on International Agricultural Research, October 1978).

3. See James K. Boyce and Robert E. Evenson, *Agricultural Research and Extension Programs* (New York: Agricultural Development Council, 1975), pp. 83-96. In reviewing the evidence on the congruence between commodity research expenditure and commodity value ratios, Boyce and Evenson noted that "the low income countries . . . have lower research-commodity congruence than the more mature research systems" and that "almost every region has moved toward congruence over time" (pp. 95, 96). An alternative label for the "parity model" might be the "congruence model" of research resource allocation.

4. See U.S. Department of Agriculture and Association of State Universities and Land Grant Colleges, *A National Program of Research for Agriculture* (Washington, D.C.: U.S. Government Printing Office, 1966). The classification scheme developed in 1966 has been modified as it has been implemented and used. See Agricultural Research Advisory Committee, *Manual of Classification of Agricultural and Forestry Research: Classifications Used in Current Research Information System* (Washington, D.C.: U.S. Department of Agriculture, January 1978 revision). For a discussion of related efforts among other OECD countries, see G. Wansink, "Co-operation in Current Research Information" (Paris: OECD Directorate for Food, Agriculture, and Fisheries, September 1979).

5. This section depends very heavily on J. D. Ramalho de Castro and G. Edward Schuh, "An Empirical Test of an Economic Model for Establishing Research Priorities: A Brazil Case Study," in *Resource Allocation and Productivity in National and International Agricultural Research*, Thomas M. Arndt, Dana C. Dalrymple, and Vernon W. Ruttan, eds. (Minneapolis: University of Minnesota Press, 1977), pp. 498-525. For a more technical treatment of the gains and losses from technical change, see Yujiro Hayami and Robert W. Herdt, "Market Price Effects of Technical Change on Income Distribution in Semi-subsistence Agriculture," *American Journal of Agricultural Economics*, 59 (May 1977), pp. 245-56; Per Pinstrup-Andersen, Norha Ruiz de Londono, and Edward Hoover, "The Impact of Increasing Food Supply on Human Nutrition: Implications for Priorities in Agricultural Research and Policy," *American Journal of Agricultural Economics*, 58 (May 1976), pp. 131-42.

6. Hans P. Binswanger, *The Economics of Tractors in South Asia* (New York: Agricultural Development Council; and Hyderabad, India: International Crops Research Institute for the Semi-arid Tropics, 1978); John H. Sanders and Vernon W. Ruttan, "Biased Choice of Technology in Brazilian Agriculture," in *Induced Innovation: Technology, Institutions and Development*, Hans P. Binswanger, Vernon W. Ruttan, and others, eds. (Baltimore: Johns Hopkins University Press, 1978), pp. 276-96.

7. This section on scoring models depends very heavily on the following sources: U.S. Department of Agriculture and Association of State Universities and Land Grant Colleges, *A National Program of Research for Agriculture*; J. C. Williamson, Jr., "The Joint Department of Agriculture and State Experiment Stations Study of Research Needs," in *Resource Allocation in Agricultural Research*, Walter L. Fishel, ed. (Minneapolis: University of

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Minnesota Press, 1971), pp. 289-301; Arnold Paulson and Donald R. Kaldor, "Evaluation and Planning of Research in the Experiment Station," *American Journal of Agricultural Economics*, 50 (December 1968), pp. 1149-62; John F. Malstede, "Long-range planning at the Iowa Agricultural and Home Economics Experiment Station," in *Resource Allocation in Agricultural Research*, Walter L. Fishel, ed. (Minneapolis: University of Minnesota Press, 1971), pp. 326-43; C. Richard Schumway and R. J. McCracken, "Use of Scoring Models in Evaluating Research Programs," *American Journal of Agricultural Economics*, 57 (November 1975), pp. 714-18; C. Richard Schumway, "Models and Methods Used to Allocate Resources in Agricultural Research: A Critical Review," in *Resource Allocation and Productivity in National and International Agricultural Research*, Thomas M. Arndt, Dana G. Dalrymple, and Vernon W. Ruttan, eds. (Minneapolis: University of Minnesota Press, 1977), pp. 436-60; Roland R. Robinson, "Administration of Federal Agricultural Research Funds by the Science and Education Administration: Cooperative Research" (Washington, D.C.: USDA, SEA/CR, September 1978); and George Norton and Jeffrey S. Davis, "Review of Methods Used to Evaluate Returns to Agricultural Research," in *Evaluation of Agricultural Research*, George W. Norton, Walter L. Fishel, Arnold A. Paulsen, and W. Bert Sundquist, eds. (St. Paul: University of Minnesota Agricultural Experiment Station, Miscellaneous Publication 8-1981, April 1981), pp. 26-47.

8. "Delphi is a formalized method designed to promote consensus without obscuring variations in evaluation or scoring. It consists of a series of individual interrogations to a group of experts, interspersed with information and opinion feedback. Some questions inquire into the reasons for previously expressed opinions. A collection of such reasons is then presented to each respondent who is invited to reconsider his earlier estimate. Delphi attempts to improve the committee approach by subjecting views of individual experts to each other's criticism in ways that avoid face to face confrontation" (C. Richard Schumway, "Models and Methods to Allocate Resources," p. 448). See also Yao-chi Lu, "Ex Ante Evaluation of the Separate Effects of Research and Extension," in *Evaluation of Agricultural Research*, George W. Norton, Walter L. Fishel, Arnold A. Paulsen, and W. Bert Sundquist, eds. (St. Paul: University of Minnesota Experiment Station, Miscellaneous Publication 8-1981, April 1981), pp. 240-46.

9. The methodology employed at the CIAT has been described by Per Pinstrup-Andersen and David Franklin, "A Systems Approach to Agricultural Research Resource Allocation in Developing Countries," in *Resource Allocation and Productivity in National and International Agricultural Research*, Thomas M. Arndt, Dana G. Dalrymple, and Vernon W. Ruttan, eds. (Minneapolis: University of Minnesota Press, 1977), pp. 416-35; and by John H. Sanders and John K. Lanam, "Definition of the Relevant Constraints for Research Resource Allocation on Crop Breeding Programs," *Agricultural Administration* (forthcoming, 1981). For a description of the IRRI's methodology, see S. K. De Datta, K. A. Gomez, R. W. Herdt, and R. Barker, *A Handbook on the Methodology for an Integrated Experiment-Survey on Rice Yield Constraints* (Los Banos, Laguna, Philippines: International Rice Research Institute, 1979). For a review of recent developments in this field of crop-loss modeling, see W. Clive James and P. S. Teng, "The Quantification of Production Constraints Associated with Plant Diseases," in *Applied Biology*, vol. 4, T. H. Coaker, ed. (London: Academic Press, 1979).

10. This section depends primarily on George W. Ladd and Craig Gibson, "Micro Economics of Technical Change: What's a Better Animal Worth?" *American Journal of Agricultural Economics*, 60 (May 1978), pp. 236-40; Bryan E. Melton, "Basic Breeding Concepts and Relations," in *Applications of Economics in Animal Breeding*, George W. Ladd, ed. (Ames, Iowa: Iowa State University, Department of Economics Staff Paper No. 98, October 1979); Yoav Kislev and Uri Rabiner, "Economic Aspects of Selection in the Dairy Herd in Israel," *Australian Journal of Agricultural Economics*, 23 (August 1979), pp. 128-46.

11. D. N. Baker, J. D. Hosketh, and W. G. Duncan, "Simulation of Growth and Yield in Cotton," *Crop Science*, 12 (1972), pp. 431-39. I have also had the benefit of a memorandum from J. D. Hasketh (USDA Crop Production Systems Research, Mississippi State University) to Walter L. Fishel (USDA Systems and Policy Analysis, Agricultural Research Service), "Status of Simcot II—A Model for Predicting Cotton Growth and Yield," 1977.

12. This section depends primarily on Walter L. Fishel, "The Minnesota Research Resource Allocation Information System and Experiment," in *Resource Allocation in Agricultural Research*, Walter L. Fishel, ed. (Minneapolis: University of Minnesota Press, 1971), pp. 344-81; K. William Easter and George Norton, "Potential Returns from Increased Research Budget for the Land Grant Universities," *Agricultural Economics Research*, 29 (October 1977), pp. 127-33; A. A. Araji, J. R. Sim, and R. L. Gardner, "Returns to Agricultural Research and Extension Programs: An Ex Ante Approach," *American Journal of Agricultural Economics*, 60 (December 1978), pp. 964-68; Norton and Davis, "Review of Methods Used to Evaluate Returns to Agricultural Research."

13. Vernon W. Ruttan, "The Contribution of Technological Progress to Farm Output: 1950-75," *Review of Economics and Statistics*, 38 (February 1956), pp. 61-69. For another evaluation of the same material, see J. D. Black and J. T. Bonnen, *A Balanced United States Agriculture in 1965* (Washington, D.C.: National Planning Association Special Report No. 42, 1956).

14. G. Edward Schuh, "O Potencial de Crescimento da Agricultura Brasileira: Algumas Alternativas e suas Consequências" (Brasília: EAPA/SUPLAN, Ministerio da Agricultura, 1972).

15. Yao-chi Lu, Philip Cline, and Leroy Quance, *Prospects for Productivity Growth in U.S. Agriculture* (Washington, D.C.: U.S. Department of Agriculture, Economics, Statistics, and Cooperative Service, Agricultural Economic Report No. 435, September 1979).

16. The lag analysis is similar to that developed by Robert E. Evenson, "The Contributions of Agricultural Research and Extension to Agricultural Productivity" (Ph.D. dissertation, University of Chicago, 1968). The implications of different approaches to lag analysis have been explored by Jeff Davis in "A Comparison of Alternative Procedures for Calculating the Rate of Return to Agricultural Research Using the Production Function Approach" (St. Paul: University of Minnesota, Department of Agricultural and Applied Economics Staff Paper No. P79-19, May 1979).

17. Sylvan H. Wittwer, "Maximum Production Capacity of Food Crops," *Bioscience*, 24 (April 1974), pp. 216-24. The 12 areas identified as having significant productivity impact potential were (1) enhancement of photosynthetic efficiency, (2) water and fertilizer management, (3) crop pest-control strategies, (4) controlled environment or greenhouse agriculture, (5) multiple and intensive cropping, (6) reduced tillage, (7) bioregulators, (8) new crops, (9) bioprocessing, (10) antitranspirants, (11) development of plants to withstand drought and salinity, and (12) twinning. See Lu, Cline, and Quance, *Prospects for Productivity Growth*, p. 40.

18. D. G. Russell, "Resource Allocation in Agricultural Research Using Socio-economic Evaluation and Mathematical Models," *Canadian Journal of Agricultural Economics*, 23 (July 1975), pp. 29-52.

19. For a less optimistic view, see Edwin Mansfield, "The Evaluation of Industrial Research and Development Projects," in *Evaluation of Agricultural Research*, George W. Norton, Walter L. Fishel, Arnold A. Paulsen, and W. Bert Sundquist, eds. (St. Paul: University of Minnesota Agricultural Experiment Station, Miscellaneous Publication 8-1981), pp. 213-18.

RESEARCH PRIORITIES AND RESOURCE

ALLOCATION IN AGRICULTURE: THE CASE OF COLOMBIA

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RESEARCH PRIORITIES AND RESOURCE ALLOCATION IN AGRICULTURE: THE CASE OF COLOMBIA

The purpose of this paper is to analyze the present ongoing experience of formulating a National Plan for Agricultural Research in Colombia. Emphasis is placed not on the substantive content of the plan (i.e., objectives, strategy, and research programs proposed), but on the methodological aspects involved in its formulation. Special attention is given to the criteria and the methodological framework that is being used in the process of identifying technological requirements and research priorities (both in terms of agricultural products and of research topics or issues), as an instrument of resource allocation in this sector.

The first section of this paper provides general information with respect to the present situation and orientation of agricultural research activities in Colombia. The objective here is to give a very broad characterization of the present research effort in the country, in terms of the areas it covers and in terms of the financial and human resources that are dedicated to it.

The second section analyzes the general methodological framework for the identification of research priorities that is presently being used in the formulation of the National Plan for Agricultural Research in Colombia. The approach that is being used is characterized in terms of two main phases:

a) The identification of socio-economic priorities in terms of products or problem-areas.

b) The determination of technological requirements and research needs within selected products or problem-areas.

The Colombian experience with respect to the implementation of these two phases is analyzed in section 3 (first phase) and in section 4 (second phase). The institution that has been responsable for the formulation of this research plan in Colombia has been the "Instituto Colombiano Agropecuario (ICA)", with the active collaboration of COLCIENCIAS (Colombian Fund for Scientific and Technological Research) and the National Planning Agency (D.N.P.). The strategy and methodology used in the formulation of this plan (analyzed in section 4) was developed by the research people of ICA.

1. Agricultural Research in Colombia: Institutional Infrastructure and Present Orientation

1.1 Introduction

The first part of this paper presents the results of the study conducted by IDRC on the way in which resources (financial resources in particular) are allocated for agricultural research in Colombia 1/. The study focused on six institutions and the university sector. The institutions analyzed were: Instituto Colombiano Agropecuario (ICA) (The Colombian Agricultural Institute); Centro Nacional de Investigaciones del Café (CENICAFE) (The National Coffee Research Institute); Corporación Nacional de Investigación y Fomento Forestal (CONIF) (The National Research and Forestry Development Corporation); Corporación Autónoma Regional del Cauca (CVC) (The Cauca Valley Corporation); Centro Internacional de Agricultura Tropical (CIAT) (The International Tropical Agriculture Centre); and Instituto Nacional de los Recursos Renovables y del Ambiente (INDERENA) (The National Institute of Natural Resources and the Environment). Information on universities doing some type of agriculturally-related research was also examined and summarized. ICA is the most important institution studied since it is the leading agricultural research centre in the country.

It is important to note that this study only considered financial resources spent on agro-biological research.

1.2 Expenditure in Agricultural Research

1.2.1 R and D Expenditure at the National Level

Table 1 shows the total amount of financial resources that the previously mentioned institutions spent in research from 1972 to 1976. 2/ ICA's share of total research expenditure during this period was 83.5%. However, the table indicates that ICA's share has declined in recent years; in 1973 it accounted for 84.8% of total resources spent on agricultural research, but in 1976 this percentage dropped to 80.3%. During this same period CENICAFE occupied second place after ICA in terms of research expenditure with 10.0%. INDERENA spent an average of 3.0% of total resource expenditure during this period, and universities accounted for 3.6%. The CVC share made up no more than 0.9% of the total.

1/ IDRC. Project ARIAL. Asignación de Recursos para Investigación en América Latina. Colombia: Estudio de Caso. February, 1980.

2/ In order to convert the information on financial resources given in this paper from Colombian pesos to U.S. dollars, the following rates of exchange should be used for the different years: 1970: $18.45 Colombian pesos for one dollar (this rate should be used for all amounts given in constant 1970 values); 1972: $21.87; 1974: $26.06; 1976: $34.70; and 1978: $39.10.

Table 1

Colombia: Total Expenditure in Agricultural Research

(in thousands of Colombian pesos)

Institutions	1972	1973	1974	1975	1976
ICA	151,200	175,500	188,100	236,700	266,700
Cenicafe	-	15,674	23,881	31,584	37,227
Inderena	-	9,047	9,481	9,503	9,023
Conif	-	-	-	3,053	2,813
CVC	-	-	-	1,928	3,136
Universities	4,576	6,776	7,143	10,812	13,401
TOTAL	157,776	206,997	228,605	293,580	332,300
TOTAL (in constant 1970 values)	124,422	135,469	117,233	124,610	114,114

Source: IDRC. Op. cit.

This table also shows that although total agricultural research expenditure formally increased from 1972 to 1976 (in current values), passing from $157,776,000 to $332,300,000 Colombian pesos, in real terms (at constant 1970 values) there has been an overall decline in the amount of funds allocated for research. Total research expenditure was $124,422,000 in 1972, and only amounted to $114,114,000 in 1976 (at constant 1970 values) 3/.

Table 2 shows the breakdown of agricultural research expenditure in terms of the different crops and agricultural products, as well as the relationship between research expenditure and value of production for each product (third section of Table 2). In most cases the percentage of research expenditure over value of production is less than 0.20%, with a few extreme examples (i.e. oats and sheep) in which the high percentage is due to the very small value of that crop's production in the country. In those cases, even a modest research expenditure represents a high percentage in terms of this relationship.

Two additional factors should be pointed out with respect to Table 2. In the first place, the research expenditure figures for the different crops slightly underestimate the investment level in each crop, since these amounts only include the cost of the respective research programs, but do not include the maintenance costs and investments related to the research stations and centres in which these programs are carried out. This latter aspect appears as a separate expenditure component in Table 2 (see last row). At the aggregate level, total agricultural research expenditure represents 0.33% of the total value of agricultural production in Colombia (with only slight variations between 1972 and 1976).

Secondly, a more significant relationship to analyze is that of agricultural research expenditure as a percentage of the agricultural gross domestic product (G.D.P.), since the latter only includes the value added by this sector. Nevertheless, the breakdown of agricultural GDP in terms of the different crops and agricultural products is not available.

At the sectorial level, Table 3 shows the evolution of the relationship between total agricultural research expenditure and the GDP of the country (both total GDP and agricultural GDP). This table clearly shows the deterioration of the proportion of agricultural GDP that is allocated to research in this sector. In 1972 this proportion was that of 0.32%, which was substantially higher than the overall relationship between total national R and D expenditure (for all sectors) and total GDP (estimated by COLCIENCIAS to be 0.20% in 1972). By 1976 this situation had drastically changed, with agricultural research expenditure dropping to 0.22 of agricultural GDP. A somewhat less negative evolution is

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3/ This does not include CIAT expenditures in this area, since CIAT is an international agency and this information would distort the national research picture.

Table 2

Colombia: Relationship Between Research Expenditures and Value of Production by Agricultural Product

(in thousands of Colombian Pesos and percentages)

Product	Value of Production (A)					Research Expenditure (B)					B/A = %				
	1972	1973	1974	1975	1976	1972	1973	1974	1975	1976	1972	1973	1974	1975	1976
Coffee	6,701,590	8,540,240	10,446,400	13,707,100	27,182,640	350*	10,155	12,294	16,123	15,506	-	0.119	0.118	0.118	0.057
Rice	1,880,230	3,808,710	5,668,660	6,315,580	6,405,360	2,834	2,979	2,884	4,380	5,452	0.151	0.078	0.051	0.069	0.085
Oats	-	1,760	2,160	3,900	3,700	758	1,667	1,147	637	704	-	94.715	53.102	16.333	19.027
Barley	201,586	247,476	354,147	660,386	444,886	758	1,021	897	925	704	0.376	0.423	0.253	0.140	0.158
Maize	1,749,450	2,460,130	2,662,600	2,964,820	4,288,590	4,934	5,602	6,901	6,732	7,522	0.226	0.173	0.185	0.161	0.125
Sorghum	432,390	778,400	1,069,970	1,205,660	1,750,000										
Wheat	173,968	202,358	264,364	251,527	290,554	1,501	1,931	2,790	3,648	4,021	0.863	0.954	1.055	1.450	1.384
Potatoe	1,190,880	5,703,490	2,241,580	5,335,440	4,478,260	4,053	4,196	4,292	5,994	6,724	0.980	0.051	0.063	0.050	0.064
Cassava	2,945,730	2,635,360	4,579,320	6,572,290	6,045,710										
Yam	-	182,597	178,448	243,975	281,766	-	-	-	-	-	-	-	-	-	-
Sugar Cane	920,112	-	-	-	-	1,137	1,268	1,071	1,675	270	-	-	-	-	-
"Panela"	1,987,290	2,814,240	2,524,120	2,710,040	7,562,820	-	-	-	1,772	4,749	-	-	-	0.065	0.063
Cotton	2,107,470	2,948,910	3,937,790	4,120,030	6,894,300	2,436	2,258	2,069	2,625	3,011	0.116	0.077	0.053	0.064	0.044
Sesame	147,698	110,555	177,315	239,685	271,411										
Peanuts	-	3,213	5,313	14,250	18,260										
African Palm	-	427,328	740,765	612,304	683,038	4,058	5,117	5,158	7,417	7,784	[illegible]	0.532	0.319	0.364	0.494
Soybean	336,210	421,562	691,638	1,172,180	603,900										
Vegetables & Fruits	-	-	-	-	-	4,456	5,005	4,578	6,878	7,754	-	-	-	-	-
Sisal Hemp	-	-	-	-	-	-	-	-	-	270	-	-	-	-	-
Cocoa	288,180	423,589	565,915	616,812	889,104	2,764	3,620	3,282	4,587	4,749	[illegible]	0.853	0.580	0.744	0.534
Tobacco	298,800	609,800	673,056	1,154,200	1,088,800	1,098	1,099	1,297	2,062	2,108	0.367	0.180	0.193	0.179	0.194
Grain Leg. (Beans)	504,136	523,935	913,097	1,667,100	1,388,570	2,975	3,726	4,287	4,662	4,908	0.590	0.711	0.470	0.280	0.353
Bananas	600,000	1,051,180	1,473,340	1,857,670	2,963,010	952	1,358	1,388	1,772	2,082	0.038	0.041	0.030	0.255	0.230
Plantain	1,918,130	2,251,380	3,178,340	5,101,820	6,082,110										
Cattle	13,205,720	14,543,200	18,329,420	16,773,310	18,165,494*	8,717	9,740	9,515	14,048	15,652	0.065	0.067	0.052	0.084	-
Pigs	2,219,000	3,510,900	3,318,400	5,517,400	7,476,077*	2,580	3,404	2,679	4,875	9,261	0.116	0.097	0.081	0.088	-
Sheep	30,799	40,340	54,300	84,110	92,310	1,887	2,132	1,960	2,577	2,929	6.127	5.285	3.577	3.064	3.173
Poultry	3,582,720	5,001,300	6,820,710	8,577,250	11,476,360*	2,726	3,386	2.439	5,684	5,103	0.076	0.068	0.036	0.066	-
Minor Species	-	-	-	-	-	-	-	100	387	1,332	-	-	-	-	-
Forestry	927,000	1,216,000	1,770,000	1,950,000	2,668,000	200	200	267	3,937	4,222	0.022	0.016	0.015	0.202	0.158
Fishery	915,000	1,036,000	1,598,000	1,920,000	2,534,000	1,608	11,819	12,503	15,197	15,294	0.176	1.141	0.782	0.792	0.604
Basic Research						24,361	29,211	31,053	42,868	48,116					
Support Research						10,319	14,699	15,746	20,963	28,412					
Operation research centres						68,314	80,203	96,476	108,520	121,313					
TOTAL	45,264,089	61,493,953	74,239,688	91,348,839	122,036,039	155,776	[illegible]	228,605	293,580	333,300	0.344	0.337	0.308	0.321	0.272

* Estimated

Source: IDRC. Op. Cit.

Table 3

Colombia: Relationship Between Total Agricultural Research Expenditures and Gross Domestic Product (Total G.D.P. and Agricultural G.D.P.)

(in thousands of Colombian pesos and percentages)

Years	Total Agricultural Research Expenditure (a)	Total GDP (b)	Agricultural GDP (c)	% (a/b)	% (a/c)
1972	157,776	186,092,300	49,465,000	0.09	0.34
1973	206,997	243,235,900	66,746,000	0.09	0.31
1974	228,605	329,155,400	88,477,600	0.07	0.26
1975	293,580	412,828,700	113,484,800	0.07	0.26
1976	332,300	532,960,800	148,956,300	0.06	0.22

Source: IDRC. Op. cit.

observed with respect to total GDP (Table 3) and total value of agricultural production (third section of Table 2).

1.2.2 Distribution of R and D Expenditure in ICA

More in-depth information is provided here on this institution since it is the leading agricultural research centre in the country. Table 4 shows how the distribution of ICA research funds has evolved from 1970 to 1978. Research activity has tended to decline. Even though total ICA expenditures have increased even in real terms, allocations for research have dropped in real terms by $21,000,000, or 17.0%. Research went from constituting 41.1% of the total ICA budget in 1970 to 27.7% in 1978.

A breakdown of the total ICA budget during the period in question shows that this institution has been increasingly assigned more functions and duties, but has not received a proportionate increase in budget funds. Consequently, the institute's different departments compete for available resources; research, formerly the most important ICA activity, has been negatively affected by this situation in terms of being able to sustain the pace of research projects, undertaking new projects in response to emerging agricultural needs and losing qualified staff.

ICA research can be divided into two categories: agricultural and livestock. These categories can be further divided into basic research and research on specific products. Basic research, which will not be discussed here, includes crop production, seasons, grasses and fodder and special projects.

Table 5 presents the information gathered in the IDRC study for the period between 1970 and 1976. It shows that agricultural research represented more than half of the total resources spent by this institution in research. Product research, rather than basic research, predominates in both the agricultural and livestock categories. A brief discussion of these research areas follows:

a) Agricultural Product Research 4/

The most important sub-group, in budget terms, in the agricultural product research category, is grains and cereals. Table 6 indicates that the maize and sorghum program is the main one 5/ since its share in total ICA budget expenditure for this period is the highest. Rice and

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4/ This analysis of research expenditures and economic importance does not include coffee, which is the principal agricultural product in the economy. The National Federation of Coffee Growers conducts the research done on this product, which receives the largest amount of research funds.

5/ Estimates indicate that almost 80% of the activities in this program are focused on maize.

Table 4

Colombia - ICA: Distribution of the ICA Budget in Terms of Different Activities

(in millions of Colombian Pesos)

Activity:	1970	1971	1972	1973	1974	1975	1976	1977	1978
Administration	43.6	43.1	47.3	49.9	51.9	88.8	92.3	106.7	137.8
Debt Service	-	0.1	1.9	6.8	12.4	28.6	60.6	63.9	73.8
Rural Development	51.0	57.9	69.3	89.4	103.0	117.2	149.1	199.3	301.8
Research	121.3	143.6	151.2	175.5	188.1	236.7	266.7	307.8	420.4
	(121.3)*	(130.0)*	(120.8)*	(114.9)*	(96.5)*	(100.7)*	(91.6)*	(88.4)*	(100.9)*
Agricultural Production	16.0	21.5	30.8	36.3	43.3	52.9	62.5	78.4	88.9
Livestock Production	26.1	44.0	55.4	73.6	89.2	151.8	171.7	162.7	230.5
Physical Investments and Others	37.1	54.6	56.1	13.7	18.7	32.2	40.6	99.2	262.1
TOTAL	295.1	364.8	412.1	445.1	506.7	708.2	843.5	1.018.1	1.515.3
	(295.1)*	(332.2)*	(329.1)*	(291.6)*	(259.8)*	(301.4)*	(298.7)*	(292.2)*	(363.7)*

Source: IDRC. Op. cit.

* The figures in parenthesis are expressed in constant 1970 values.

Table 5

Colombia - ICA: Percentage Participation of Agricultural and Livestock Research in Total Research Expenditures 1/

Years	AGRICULTURAL RESEARCH			LIVESTOCK RESEARCH				Support Research *	Total Research
	Research Programs on Crops	Basic Research	Total	Program-Product	Basic Research	Other	Total		
1972	41.3	17.6	58.9	19.2	9.5	4.2	32.8	8.3	100.0
1973	39.4	16.2	55.7	18.8	11.2	2.5	32.5	11.8	100.0
1974	40.0	18.1	58.1	16.3	10.9	3.8	30.9	11.0	100.0
1975	38.2	17.3	55.5	19.1	11.2	4.3	34.6	9.9	100.0
1976	36.3	16.2	52.5	19.8	11.3	5.0	36.1	11.4	100.0

Source: IDRC. Op. cit.

1/ This table does not include the operational costs of the agricultural research stations.

* This includes such things as: Biometry, Agricultural Resources, Agricultural Machinery, Regional Agricultural Economy, etc.

Table 6

Colombia - ICA: Percentage Participation of Each Crop in Total Research Expenditure

Crops	1972	1973	1974	1975	1976
Cereals:	13.0	13.2	14.5	11.5	11.1
Rice	3.4	3.0	2.9	3.1	3.3
Oats	0.9	1.7	1.1	0.4	0.4
Barley	0.9	1.0	0.9	0.6	0.4
Maize & Sorghum	6.0	5.6	6.8	4.8	4.6
Wheat	1.8	1.9	2.8	2.6	2.4
Starchy Crops:	6.1	5.6	5.6	5.5	5.4
Potatoes and cassava	4.9	4.2	4.2	4.2	4.1
Plantain and bananas	1.2	1.4	1.4	1.3	1.3
Sugars:	1.3	1.3	1.1	2.5	2.9
"Panela" (Sugar Loaf)	-	-	-	1.3	2.9
Sugar Cane	1.3	1.3	1.1	1.2	-
Oil Seeds:	7.8	7.4	7.1	7.2	6.5
Perennial	4.9	5.1	5.1	5.3	4.7
Cotton	2.9	2.3	2.0	1.9	1.8
Other Crops:	13.0	11.9	11.7	11.7	10.5
Cocoa	3.3	3.6	3.2	3.3	2.9
Vegetables and Fruits	5.0	4.0	3.5	4.0	3.7
Grain Legumes and Annual Oil Seeds	3.4	3.2	3.7	2.9	2.6
Tobacco	1.3	1.1	1.3	1.5	1.3
TOTAL	41.3*	39.4*	40.0*	38.2*	36.3*

* This refers to the total percentage allocation to research programs on crops (see first column of Table 5)

Source: IDRC. Op. cit.

wheat occupy second and third place after maize and sorghum 6/. These are the most important products in economic terms when you consider the area sown with them and their production value. These products also receive the highest research priority.

The potato and cassava program has also received significant budget allocations, placing it in second position after the cereal and grain program. These two products also have a substantial share of production value. Over the last five years, ICA has increased budget allocations for the fruit and vegetable program because it covers essential food items included as high priority in integral rural development plans and food and nutrition programs.

Research on "Panela" (sugar loaf) also appears important among total research expenditures, as a result of the concern the government has shown for this basic subsistence crop grown in five regions of the country.

Finally, it is important to note that although some products like bananas represent a considerable part of the production value, ICA has not given them top research priority. This particular commercial crop (bananas) is primarily used for export.

b) Livestock Research by Product

The dairy and beef programs account for a significant share of ICA research funds spent on livestock programs/products, as shown in Table 7. The pork program occupies third place in terms of budget allocations for livestock research, but shows the highest growth rate, while the products that hold first and second place show negative growth rates.

c) Basic Agricultural and Livestock Research

Tables 8 and 9 provide the information on basic research in these two fields. The soil and plant pathology programs occupy first place in basic research. Entomology and plant physiology have a lower share of funds for basic research. Generally speaking, priority has been given to those disciplines whose aim is to control both plant and animal pests and diseases.

6/ Although wheat is an important cereal, it is not very important in terms of the amount of funds allocated for research. At the economic level, its contribution to production value is not significant. Maize has fundamentally become an imported product.

Table 7

Colombia - ICA: Percentage Participation of Animal Products in Total Research Expenditures

Animal Program-Product	1972	1973	1974	1975	1976
Beef Cattle	4.3	3.8	4.0	4.9	4.5
Dairy Cattle	6.3	6.0	5.4	5.0	5.0
Pigs	3.1	3.4	2.5	3.2	5.4
Sheep	2.3	2.1	1.9	1.8	1.8
Poultry	3.3	3.4	2.4	4.0	2.9
Minor Species	-	-	-	0.2	0.3
TOTAL	19.2*	18.8*	16.3*	19.1*	19.8*

* This refers to the total percentage allocation to program-product livestock research (see fourth colum of Table 5).

Source: IDRC. Op. Cit.

Table 8

Colombia - ICA: Percentage Participation of Main Disciplines Related to Basic Agricultural Research in Total Research Expenditure

	1972	1973	1974	1975	1976
Entomology	3.4	2.1	3.2	2.6	2.9
Plant Physiology	3.1	3.0	3.0	2.6	2.6
Plant Patology	4.4	4.5	4.9	4.5	4.2
Soils	6.7	6.6	7.1	7.6	6.4
TOTAL	17.6*	16.2*	18.1*	17.3*	16.2*

* This refers to the total percentage allocation to basic agricultural research (see the second column of Table 5).

Source: IDRC. Op. cit.

Table 9

Colombia - ICA: Percentage Participation of Main Disciplines Related to Basic Livestock Research in Total Research Expenditure

	1972	1973	1974	1975	1976
Animal Physiology	0.8	0.9	1.2	1.0	1.0
Microbiology	3.6	4.5	4.5	3.9	4.1
Nutrition	0.8	0.9	1.0	0.8	0.7
Parasitology	1.5	2.0	1.5	1.8	1.1
Pathology	2.3	2.5	2.1	2.1	2.2
Toxicology	0.4	0.5	0.7	0.5	0.5
Epidemiology	-	-	-	0.2	0.4
Vascular Diseases	-	-	-	1.1	1.3
TOTAL	9.5*	11.2*	10.9*	11.2*	11.3*

* This refers to the total percentage allocation to basic livestock research (see the fifth column of Table 5).

Source: IDRC. Op. cit.

1.2.3 Implicit Research Priorities for Agricultural Products in ICA

On the basis of the previous tables, implicit research priorities for agricultural products can be identified, according to the amount of funds spent:

a) High priority: maize and sorghum, perennial oleaginous products, potatoes and cassava, fruits and vegetables and rice.

b) Middle priority: legumes and annual oleaginous products, sugar cane for sugar loaf (panela), cocoa, cotton, wheat and tobacco.

c) Low priority: plantains and bananas, sugar cane, barley and oats.

1.3 Human Resources in Agricultural Research

1.3.1 General Trends in the Development of Human Resources

An ICA study 7/ showed that the evolution of this institution's human resources have two main characteristics:

a) In 1974 the research department of ICA had the highest concentration of university trained professionals in the institution, either at the bachelor's, M.S. or Ph.D. levels. By 1979, the relative importance of this department in terms of the number of professionals working in it had diminished. In the case of bachelor-degree professionals, even the absolute number of persons working in this department diminished (see Table 10).

b) Although most of the M.S.'s and Ph.D.'s working in the institute work in research, the percentage of them working in this area has been on the wane.

Table 10 presents information on human resources in terms of educational level and departments in ICA.

1.3.2 Brain-Drain: Migration of Researchers 8/

Between 1960 and 1978, 652 persons were trained at the M.S. and Ph.D level. Of this group, 396 professionals were still working in ICA in 1978, and 256 had left. More important than this, the number of graduate level professionals

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7/ ICA. Diagnóstico de la Investigación Agropecuaria. 3 volumes. Bogotá, June, 1979. (Unpublished).

8/ Based on the document: IICA. Sistemas Nacionales de Investigación Agropecuaria en América Latina: Análisis Comparativo de los Recursos Humanos en Países Seleccionados. El caso del Instituto Colombiano Agropecuario (ICA). Vol. III.2 Bogotá, 1979.

Table 10

Colombia - ICA: Professional Personnel by Levels of Education

1974, 1976, 1979

Department	Bachelor's Degree			M.S.			Ph.D.			TOTAL		
	1974	1976	1979	1974	1976	1979	1974	1976	1979	1974	1976	1979
Research	406	205	137	77	155	145	34	32	39	517	392	321
Rural Development	256	190	149	22	76	88	1	7	6	279	273	243
Livestock Production	279	220	120	14	23	26	2	4	2	295	247	148
Agricultural Products	120	95	42	8	26	24	2	3	2	130	124	68
Transfer of Technology	-	-	222	-	-	17	-	-	-	-	-	239
Administration & Planning	106	64	59	17	23	20	2	5	2	125	92	81
TOTAL	1.167	774	729	138	303	320	41	51	51	1.346	1.128	1.100

Source: ICA. Diagnóstico de la Investigación Agropecuaria. Bogotá, June, 1979, page 141. Three volumes (unpublished).

who have left ICA has increased more rapidly than the number of those who have been hired.

A recent study on the evolution of the human resources of ICA shows the following trend 9/:

Period	No. of researchers trained at graduate level	No. of researchers leaving ICA	B/A: %
	(A)	(B)	
1960-67	63	2	3.1
1968-74	186	50	26.9
1975-78	104	55	52.3

Thus, there is a definite trend towards a higher migration of researchers, coupled with less hiring of research staff. In 1978 the percentage of the former over the latter was that of 52.3% (see above). If this trend continues, the number of skilled researchers leaving the institute will outnumber those entering, and ICA will suffer a net loss of highly trained graduate level staff.

1.4 Conclusions

This very brief analysis of the situation of agricultural research in Colombia clearly points out three important trends that are having a negative impact on this sector:

a) The funds allocated for agricultural research (both at the national level and in ICA) have been decreasing in real terms (in constant 1970 values) over the last decade (Tables 1 and 4). This trend is also evident in the deterioration of the proportion of agricultural GDP that is allocated to research in this sector (Table 3).

b) During the period under analysis ICA has been increasingly assigned more functions and duties, but has not received a proportionate increase in budget funds. Consequently, the institute's different departments compete for available resources. Research, formerly the most important ICA activity, has been negatively affected by this situation, both in terms of funds allocated to it within the ICA budget (Table 4), and in terms of high-level manpower dedicated to this activity in the institution (Table 10).

9/ IICA. Op. cit. Pages 36 to 38.

c) Despite a very important effort in training of high-level manpower for research (M.S. and Ph.D. levels), carried out in the sixties and early seventies, ICA is facing an increasing problem of migration of researchers, coupled with less hiring and training of research staff. If this trend continues, its capacity to do research will be seriously impaired in the very near future.

It is in response to this deteriorating situation that the National Agricultural Research Plan was formulated. This plan as such is part of a broader package of government actions aimed at changing this situation and stopping the downward trends. The other two important measures that form part of this package are the creation of a Special Fund for Agricultural Research (different from, and additional to, the ICA budget), and the establishment of a National Council for Agricultural Research and Technology Diffusion. These last two measures are presently being considered in the Ministry of Agriculture and in Congress.

It should also be pointed out that the design and establishment of a Special Fund for Agricultural Research, raises the very important issue of identifying alternative financial mechanisms or systems for the funding of agricultural research in the country. The national budget has been the traditional source of research funds for this sector, given the centralized institutional model that has mainly operated around one large public research organization. For the creation of the special fund that has been mentioned, alternative mechanisms for the mobilization of financial resources are being considered. This also raises the issue of the participation of the private sector in agricultural research, and of mixed or joint research mechanisms between the public and private sectors.

2. A General Approach to the Process of Identifying Research Priorities in the Agricultural Sector

2.1 General Considerations

The formulation of research policies, in any field, is a way of responding to a situation in which multiple possible research topics compete for the limited financial resources that are available for supporting this activity. Furthermore, they are also a means for relating the research effort in any given country to the needs and development problems that are of major importance in that society.

Finally, research policies are also a means of influencing the characteristics and orientation of technical change and technological development in the agricultural sector, trying to make it more compatible with the "type of development" (or development objectives) that are considered to be more appropriate for that society. This third aspect leads to the broader issue of a "technological development policy" for the agricultural sector, of which the research policy is only one of several components. The orientation of technical change and technological development in the agricultural sector will depend, to a large extent, on a broad range of decisions that are taken either by governments or by the producers themselves (at the level of the production units), such as decisions relating to what products should be produced in the country and which ones should be imported, what technologies should be made available or should be used, what production systems should be promoted (i.e., cropping systems, size and type of production units, etc.). It is through these and other decisions that the "technological profile" of this sector will be determined, and the dynamics of technical change will gradually take form.

Although the supply of technical knowledge generated by research programs is one of the factors that may influence these decisions (i.e., by making some alternatives possible or feasible), the latter are most often influenced by economic policies or by market situations (both the national and the international market) that are confronted by the producer. Thus, many of these decisions are shaped by credit policies, commercialization policies, fiscal policies, monetary policies and foreign trade and foreign exchange policies. These policies may also influence the relative importance that is given to national agricultural research efforts in any given period, and thus the financial resources that are allocated to this activity in a country. The role assigned to the agricultural sector in the development process by governmental policies (i.e., its relationship to industrialization and other developmental policies), also plays a major role. A preliminary analysis of the role played by some of these economic policies in the Colombian case is outlined in section 3.1.2 of this paper.

The previous considerations clearly point out that the agricultural research policy in any country is only one of the components of the technological development policy of that sector. This paper only addresses methodological issues related to the formulation of a research policy for the agricultural sector, with marginal references to the interphase of research policies with technological development considerations and with economic policies that are of relevance to this sector.

At the most general level, research priorities can be derived from three major sources or considerations:

a) The socio-economic development policies and programs of a country, both at the global level (i.e., general development programs, foreign trade policy) and at the sectorial level (i.e., agricultural development policies, programs and priorities). The objective here is to link research efforts with the development objectives and priorities of a country.

b) Specific needs or requirements that may be identified, both in terms of general needs of the country (i.e., the need to supply certain kind of food for a specific sector of the population, or the need to make better use of local food crops or natural resources), and in terms of specific requirements or problems of agricultural production (i.e., the need to solve specific technological constraints that limit productivity in certain areas).

c) Prospective considerations with respect to future agricultural needs, future expected situations of the national and international agricultural markets, and the type of agriculture production system or food system one would like to develop in the future.

The importance of the first factor will depend on the existence of explicit and clearly defined agricultural development policies and programs in any given country. If these do not exist, or if they are formulated only in very vague and general terms (without specific priorities, development objectives and production targets), as it is quite often the case, this factor will play a lesser role in determining research priorities.

Nevertheless, even when explicit sectorial policies and development programs are clearly formulated, the criteria and guidelines derived from them should be complemented by the other two factors mentioned above. The second factor may lead to the identification of requirements or production possibilities that are not adequately dealt with in the present sectorial development programs, such as the need to develop a "cropping systems" approach, or the possibility of promoting a greater use of traditional food crops existing in the country. If these requirements or possibilities are identified, they should be taken into consideration in order to correct possible gaps in the sectorial development plans.

Finally, both existing needs and sectorial development plans are normally conceived in terms of the present and the very near future. Medium and long term perspectives are quite often absent from these considerations, or they play only a very marginal role. This third factor is the most difficult one to cope with, both in sectorial development planning efforts and in the identification and formulation of research priorities. The Colombian experience that is analyzed in the third and fourth sections of this paper deals mainly with the first two factors mentioned above. The prospective approach has not played a major role in this planning effort.

2.2 Methodological Framework for the Identification of Research Priorities

The formulation of a research policy for the agricultural sector involves three major levels of analysis:

a) The identification of agricultural products or crops which have a high socio-economic importance or priority for the development of the country. The present or potential socio-economic importance of certain crops is one of the criteria that may lead to the identification of research priorities, but, by itself, it does not define research priorities as such. The second and third factor mentioned below have to be dealt with. Moreover, research areas are not only defined in terms of agricultural products or crops; they may also be defined in terms of production problems or rural development issues, such as agricultural machinery and implements, irrigation technology and water supply, conservation and storage of crops, etc.

b) Having identified agricultural products or crops which have a high socio-economic importance for the country, the next step is that of defining which of them should receive a major attention from the point of view of research. Given a situation of limited financial resources, not all products with a present or potential socio-economic importance can be covered by the research establishment of any country. This second level of analysis raises the following questions:

- Which of these products should be produced in the country, and which ones should be imported?

- Which of these products face identifiable "technological constraints" that limit productivity, and that may lead to important research problems?

- Should the technology be generated internally (i.e., improving traditional or existing technologies), or should it simply be imported and adapted?

- Which products (research areas) should receive more support from government funds, and which ones should be left to the initiative (and financial support) of the private sector? This last question is important mainly in those countries where the private sector plays a role (or may play a role) in agricultural research.

This second step narrows down the range of products or of production problems identified as important in the first step. Some of these questions imply political decisions (policy decisions).

c) Finally, the third step consists in identifying or defining research topics or issues which are important for the solution of the "technological constraints" that limit production or productivity levels in the crops that have been selected. It is only in this third level of analysis that research priorities as such are really formulated.

The preceding considerations define a general framework for the identification of research priorities and of technological development objectives that is summarized graphically in Figure 1. The first two levels of analysis that have just been mentioned are summarized in the upper-half of Figure 1 (Socio-Economic Considerations). The output of this phase of the process is the identification of (adjusted) socio-economic product or problem priorities for research purposes. 10/ The three principal sources for identifying research priorities mentioned in section 2.1 above are taken in consideration in this diagram.

The third level of analysis previously mentioned is outlined in the lower-half of Figure 1 (Technological Considerations). This phase of the process consists in the identification of technological requirements or problems within the selected products or problem-areas, that may lead to the identification of specific research needs (and therefore research priorities). The starting point for this analysis is the identification of the principal "technological constraints" that limit production or productivity levels in specific crops under identifiable circumstances. By "technological constraints" we refer to physiological, environmental or pathological factors, as well as management systems and farming practices, that are presently an obstacle for increasing production levels or improving the efficiency of resource-utlization in specific crops or products (or even having a negative effect on these aspects).

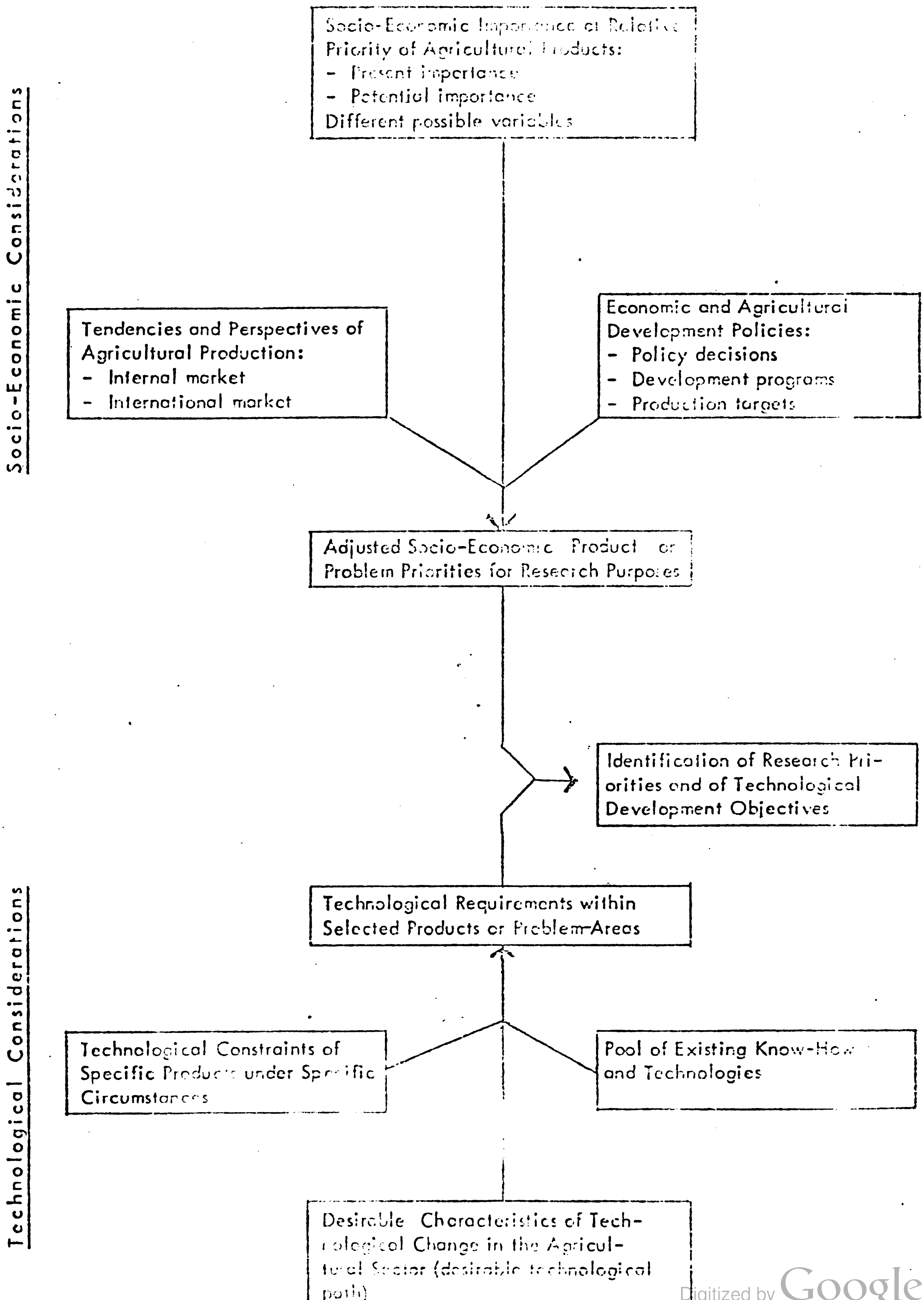
The methodology related to technological considerations presented in this paper (section 4), was taken from the experience and the work of the research branch of the Colombian Agricultural and Livestock Institute (ICA), in the formulation of the national research plan. A description of the methodology employed for the identification of research priorities is made in volume I of the Plan. *

The importance of the research effort that will have to be carried out in order to solve the technological constraints identified, will depend not only on the socio-economic importance of the product, but also on the difficulty or the

10/ It should be again emphasized that these may be slightly different from the priorities that may emerge from using only economic indicators.

* ICA: Plan Nacional de Investigación Agropecuaria del ICA, Bogotá, Volume I, 1981.

Figure 1 - Methodological Framework for the Identification of Research Priorities



magnitude of the technological problem that is confronted. For example, in those cases where the level of technological development (technological conditions of production) is considered to be quite acceptable for a specific crop in a given country, only a continous research level necessary for the maintenance of the existing high yields or disease-resisting varieties will be necessary (even in a high-priority crop). The research effort that is required (and the research priority) would be much higher, if important technological constraints are identified in a high-priority product. Thus, the order of product priority assigned on the basis of socio-economic considerations can be altered or modified in view of these technological considerations. It is for this reason that in Figure 1 the final research priorities and the technological development objectives are derived from both types of considerations.

Sections 3 and 4 of this paper describe the way this general methodological framework is being implemented in the Colombian experience. Section 3 presents two analytical models that are being simultaneously considered (and experimentally applied) in the process of defining socio-economic product priorities for research purposes (upper-half of Figure 1). These two models, although they can be used in a complementary manner, are based on a different set of variables or indicators for the identification of socio-economic priorities.

a) The first one uses jointly, and tries to relate, two major criteria for priority identification: the comparative advantage a country has in producing a given crop, and the participation of that crop in the national food consumption or total family budget (argument of food security). Furthermore, this model uses the concept of price-demand elasticity in order to determine which products should receive a higher priority in governmental support for research in them, and which ones should be basically left to the initiative and funding of the private sector (see section 3.1.3 below).

b) The second model uses as the main criteria the participation of each crop in the "total circulation of agricultural production" (this includes production for the internal market, exports and imports of agricultural products). Besides these production variables, two additional indicators are taken into consideration to see if the model gains in analytical or discriminatory power (by substantially modifying the priorities initially identified). These two additional variables are rural employment generated by each crop, and the extension of land (area under that crop's production (see section 3.2.3).

The first model is more conceptually sophisticated and formally takes into consideration a broader range of factors, including major policy decisions that have to be made as part of the process of identifying priorities (i.e., export orientation vs. food security, and public vs. private funding of agricultural research). But, on the other hand, it requires much more data, as well as the utilization of such concepts as "shadow prices" and the social costs of the use of domestic resources (land, capital and labor).

The second model is much simpler, and only requires data which is easy to use and rapidly available in any country. Its major assumption is that the participation of a crop in the "total circulation of agricultural production" has such close interrelationships with several other aspects or indicators of agricultural production (i.e., extension of land under that crop's production, total agricultural production, etc.), that it may be used as a significant approximation of socio-economic importance or priority in terms of products. For example, the two additional variables that are considered in section 3.2.3 do not add much to the priority ranking established by this basic criteria.

Section 4 analyzes the methodological process that has been used in Colombia to identify technological requirements or problems within selected products or problem-areas, and to derive research priorities from these requirements (lower-half portion of Figure 1). For this stage of the process ICA established a series of working groups covering the main crops that are produced in the country. The working methodology that they used, and that is described in section 4, has two main characteristics:

a) A matrix approach that tries to identify technological constraints that are faced by specific crops, under certain environmental conditions that define ecologically homogeneous zones. In order to use this methodology the country was regionalized and divided into such ecological zones.

b) The use of the delphic technique, at the level of the different working groups, in order to identify and analyze the technological constraints and the research needs that are faced by each crop.

The output of this process has been the formulation of "research programs" for the different crops or agricultural products under consideration. The set of research programs thus formulated, with a few other components related to general policy issues, constitute the "National Plan for Agricultural Research".

2.3 Some Observations with Respect to the Application of this Methodological Framework in the Colombian Experience

It should be noted that the two main phases of this planning process (namely, the identification of socio-economic product or problem priorities, and the determination of technological requirements and research needs within selected products or problem-areas), are supposed to be carried out in chronological sequence. That is, the determination of technological requirements and research needs within products or problem-areas, should be carried out only in those products and problems identified as having high (or significant) socio-economic importance for the country. This, of course, implies that the policy decisions that are raised by the two models discussed in section 3 have been coped with and answered.

Nevertheless, the sequence of events in real life situations does not always follows the logical ordering of methodological steps. In fact, the two phases of this planning process may overlap and be carried out simultaneously or in parallel fashion, as it happened in the Colombian experience. In this case, ICA decided to go into the identification of technological requirements and research needs at the product level (second phase), although there was still much ongoing discussion as to which were the agricultural products and problem-areas that could be considered to have a high socio-economic importance. The two models that are presented in section 3 were developed as a response to this issue. But while this first phase is still an ongoing process in Colombia (the two models are being experimentally applied), ICA has already finished formulating a first version of the research programs that should be carried out at the level of each product. Thus, the methodology of the second phase that is discussed in section 4 has already been tried out and empirically tested, having reached the stage of producing a first version of possible research programs at the product level. 11/

The analysis of the reasons for this formal discrepancy between the methodological framework or approach that has been presented, and its actual implementation in the Colombian case, gives an interesting insight into the dynamics of the planning process and into some of the practical problems that it faces.

When this planning process started, it soon became very clear that while the determination of technological requirements and research needs within products (second phase) was basically a technical endeavour, that could be easily implemented if the necessary information was available, the identification of socio-economic priorities (first phase) involved policy decisions with respect to the criteria (model) to be used and with respect to substantive economic policy issues. This being the case, the decision-making process with respect to this latter component proved to be much slower and more difficult than it had been expected. It took some time to develop and discuss the two models that are presented in section 3. 12/

In order not to stop the process of identifying research priorities and formulating research programs at the product level, until the basic issue of defining socio-economic priorities was settled (which could become a vicious circle), an alternative route was taken. It was decided to use a list of 28 products that the Ministry of Agriculture (OPSA) had drawn up, which practically represents the totality of the agricultural production of the country for which there is information (on production and commercialization). In fact, these 28 products repre-

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11/ See Plan Nacional de Investigación Agropecuaria del ICA (5 volumes), Bogotá, January, 1981.

12/ Since these two models were only very recently developed, final policy decisions with respect to the priorities that emerge from them in the Colombian case are still pending.

sent 97% of the total agricultural production. The process of identifying technological requirements and research needs within specific products (second phase) was carried out for all the 28 products.

The implications of this operational decision are quite obvious. Since the 28 products do not reflect any evaluation of socio-economic priority (it is merely a check-list of the products that are being produced in the country), the proposed research programs practically cover all the range of agricultural production, and therefore all the range of possible research topics in terms of products. 13/

Despite this limitation, this alternative was adopted for the following reasons:

a) This procedure does not invalidate the effort of identifying technological constraints and research needs within products (second phase). It merely made it a more manpower-intensive and costly process, since the exercise was carried out not only for the high-priority products but for practically all products. But, on the other hand, it was considered that this planning exercise would produce valuable information on technological constraints and problems that are faced by agricultural production in the country (even in the less-priority products).

b) Since socio-economic product priorities have not yet been established (because of the difficulties encountered in the first phase), this first version of the Plan suggests a resource-allocation procedure (and thus implicit priorities) basically in terms of the relative importance of each product from the point of view of its participation in the total agricultural production at the present time, and in terms of the need to create a basic research infrastructure in some research areas (requiring higher investment levels).

c) Finally, it was considered that the results of establishing explicit socio-economic product priorities (once the first phase of this methodological process is completed) could be incorporated "a posteriori" into the final version of the National Agricultural Research Plan, by modifying accordingly the respective importance given to the different research programs for resource-allocation purposes and, if necessary, by eliminating those programs of less-priority products.

Thus, the Colombian experience shows a complex interaction between the two major phases of the methodological framework presented in the previous section, given the need to adapt formal procedures and methodological steps to the realities and conditions of the planning process in each country.

13/ With the major exception of coffee and sugar cane, that in the case of Colombia are research areas that are in the hands of the private sector.

3. The Identification of Socio-Economic Priorities in Terms of Products

3.1 Identification of Socio-Economic Priorities in Terms of Comparative Advantages and Food Security

3.1.1 General Considerations

The theory of induced technological change, endogenous to the economic system, holds that the relative price of factors affects both the choice of existing technology as well as the biases in the use of factors in the new production functions. It has been shown empirically that the different paths of technological development taken by the United States and Japan have been determined by the relative price of factors, which reflect the different endowments these countries have in terms of land and labor.

In underdeveloped countries, it has been found that when governments establish the price of goods and factors without taking into account a country's endowment of factors, patterns of technological change are not compatible with a country's comparative advantages. In many developing countries, government policies undervalue certain kinds of products and overvalue others; the result is errors made in allocating resources for production.

Current economic theory has yet to explain why people in government make this type of error in decision-making. Of course, government leaders have political commitments, and the measures they take are politically motivated. The advocation of specific types of policy fundamentally depends on the advantage political groups hope to gain from them. Thus, a ruling political group can impose its point of view and implement price policies and technological strategies that are incongruent with a country's particular endowment of factors.

Thus, political considerations filter down to decision-making levels where resources for research are allocated; these influences can significantly distort this process. Therefore, the evolution of overall development policies, especially those policies related to agriculture, must be considered when trying to find an explanation of how funds for agricultural research are allocated.

Economics has long assigned agriculture certain functions in the economic development process. They include:

a) To increase the available food supply and to free the labor force to work in non-agricultural sectors;

b) To expand the available market for industrial products;

c) To increase domestic savings;

d) To provide foreign exchange through agricultural exports.

The analysis of closed economies generally contains the first three points. However, when dealing with an open economy and when confronted with the fourth point, the other ones no longer relate to domestic agriculture alone and could even become incompatible. The concept of comparative advantage is the relevant one, in open economies, to evaluate efficiency or inefficiency in the allocation of resources. For example, in an open economy, it is not always desirable for a country to produce its own foodstuffs, if this food could be acquired more cheaply in international markets. Therefore, the nutritional importance of a product, or other similar yardsticks, do not provide a basis for assessing the efficiency with which resources are allocated for research, unless other criteria are considered such as international prices and the cost of the domestic resources needed to produce this same product; this includes a knowledge of the opportunity costs of capital, labor, land and foreign exchange. This concept of the social costs of production and factors becomes important when you consider that the economies to be studied are riddled with distortions. For example, the market price of a product often does not represent its true social value; therefore, a person allocating resources on the basis of the production value alone can over- or under-allocate resources; this will depend on a country's current price policy, that is, whether a specific product is under- or over-valued. This in turn, depends on the priorities of the party in power.

A country may decide to ignore these considerations for political reasons or because it does not want to take risks and decides to guarantee the availability of food. Consequently, the country might allocate large quantities of resources for products that are important for the nutrition of its inhabitants. This means that at a given point in time the country in question does not have enough confidence in its ability to purchase the amount of foodstuffs it requires on the international market in order to avoid sharp fluctuations in domestic supply, or that even though a country has sufficient foreign exchange, it views food availability as essential to defending itself from outside political pressures.

Briefly then, the approach proposed here is one of an open economy in which the allocation of resources for research is based on comparative advantages and guaranteed availability of food or self-sufficiency, in terms of the world market. This approach also allows for the distortions in an economy (subsidized credit, minimum wage, tariffs, subsidies, etc.) which fundamentally influence the way resources are spent. Special emphasis is placed on the repercussions of the macroeconomic policies and development model a government adopts on agriculture in general, and on the process of generating and adopting technological change in particular.

3.1.2 The Influence of Economic Policies on Agricultural Research Trends: The Case of Colombia

The Colombian experience shows clearly that agricultural policy, and technological policy as a sub-division of this policy, are determined in the long term by the development policies and models adopted by the government and are defined in the short and medium terms by the evolution of certain important macroeconomic aggregates.

During the period of rapid industrialization between 1950 and 1967, Colombia followed the import substitution model, which tried to protect domestic production by establishing high tariffs and import quotas on consumer goods. Overvaluing the peso was another key tool in this policy and constituted, in effect, a tax on exports (primarily agricultural ones). During the 1960's when the bias towards substituting imports grew stronger, taxes on agricultural exports ran from 17 to 47%. Another means of subsidizing industrialization was to force farmers to sell raw materials such as cotton to domestic producers at prices lower than international ones. In the short term, such measures acted to discourage the production of these goods, and over the long term, they inhibited the generation and adoption of technology. Only those products for which the country had a true comparative advantage, such as coffee, sugar cane, tobacco and cotton, could withstand the pressures of this model.

At the same time, this model of rapid industrialization created the need for a large work force that received stable or declining real wages. A major part of this salary is spent on food, so the model requires that there be an abundant supply of fundamental foodstuffs. The limited foreign exchange generated by the economy must be spent on importing intermediate and capital goods necessary to boost the industrial process. Foreign exchange cannot be spent on importing food and agricultural raw materials. Therefore, credit, prices and research policies for this period stressed the production of certain foodstuffs and the import substitution of certain raw materials.

In 1967, the import substitution model gave way to the promotion of exports; trade policy and the exchange rate immediately reflected this situation. From 1970 on, exports increased considerably, and higher international prices for coffee produced more foreign exchange and a relatively large surplus in the balance of payments. This situation brought about a change of priorities in the allocation of resources. First, the importance of products that had substituted for imports declined; more wheat, corn, sorghum, oil and milk were purchased abroad. However, the excess amount of foreign exchange and its resulting monetization quickened the pace of inflation in Colombia and favored stabilization policies in the short term, so that food imports became increasingly necessary. The energy crisis occured during this same period, and more money was spent to explore for new sources of oil and to develop alternate sources of energy (hydrolectric, nuclear, etc.). All of these activities demanded large amounts of resources from the national budget.

As a consequence of this, in the mid-Seventies, the government was not only forced to curtail public spending to stabilize the budget, but most available resources went towards solving the energy crisis. Besides, with a surplus in the balance of payment, the government did not seek out foreign credit to finance research efforts. The brief description of the Colombian situation and its trade, fiscal, monetary and exchange policies helps explain why, during certain periods, the level of resources earmarked for agricultural research falls off; such has been the case of Colombia since 1970. It also helps explain why, at a given time, large quantities of resources flow towards certain types of products.

3.1.3 A Model for Identifying Product Priorities: Comparative Advantages and Food Security

When setting priorities among products for the allocation of research resources, several fundamental points must be considered: the characteristics of the country's production system -- relative availability of land, labor force, capital, foreign exchange and the social costs of each of these factors; the availability of food and raw materials used to meet nutritional needs and the country's industrial production needs; overall development models and policies; and the financial resources available for agricultural research.

Since we are working in an open economy framework and since one of the priorities in the Colombian Development Plan is to generate a stable flow of foreign exchange (anticipating later balance of payment problems), a basic criteria that must be used when allocating resources for research is the concept of comparative advantage. When a country has a comparative advantage in the production of a commodity, the net social return on producing an additional unit of this product is positive. In other words, the value of the product in terms of its shadow price (for marketable products this is the border price, CIF or FOB) should be higher than the social cost of the resource earmarked for its production. 14/

14/ The social return on a specific activity can be measured using the following formula:

$$RSN_j = \sum_{i=1}^{n} a_{ij} . P_i - \sum_{s=1}^{m} F_{sj} V_s + E_j$$

a_{ij} = The amount of the i^{th} product produced by activity j.

P_i = The shadow price of this product.

F_{sj} = The amount of S^{th} production factor used by j.

V_s = The social cost of the S^{th} factor

E_j = External effect produced by activity j.

We can calculate comparative advantage by using a parameter known as the domestic resources cost (D.R.C.). It measures the social cost, in terms of domestic resources (land, labor, capital), of generating one additional unit of foreign exchange either by exporting or by substituting imports. This cost is then compared with the average cost in the economy of generating the same unit of foreign exchange (shadow exchange rate); if the quotient is less than 1, the country has a comparative advantage in this area. 15/

For example, in 1978, it was estimated that the shadow exchange rate for Colombia was 36 pesos to the dollar. However, the domestic resources cost to substitute one dollar in maize imports was 45 pesos. In this case, Colombia did not have a comparative advantage in maize production. 16/

Using the cost structure of the different products and the percentage of imported inputs for these products, it is simple to calculate the D.R.C. and the comparative advantage; this makes it possible to work out a scale that orders products according to their comparative advantage, using 1 as the dividing point.

Nevertheless, considerations of comparative advantages cannot be used as the only criterion for resource allocation. It is necessary to combine this criterion with the second one previously mentioned, related to food self-sufficiency or guaranteed food supply. This is specially important since the National Development Plan in Colombia places great emphasis on generating a sufficient supply of food for the adequate nutrition of people, as well as on providing sufficient raw materials for agro-industry.

In order to be able to use the argument of food self-sufficiency as a criterion for setting product priorities, it is necessary to establish the weight (participation rate) that each product has in the total family budget. This is an indicator of their importance in terms of the food supply that has to be guaranteed in the country. For agricultural products used as raw materials in industrial processes (i.e., soybeans for oil), this information can be estimated by establishing the agricultural product's share in the cost structure of the industrial product, and multiplying this percentage by the industrial

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15/ The domestic resources cost can be calculated using the following formula:

$$DRC_i = \frac{\sum_{s=1}^{m} F_{si} V_s - E_i}{VAN_i} = \frac{CD_i}{VAN_i}$$

CD_i = The domestic opportunity cost of the resources used in i.

VAN = Net foreign exchange earned or saved or value added to international prices.

16/ The shadow exchange rate represents the average cost to the economy to produce one additional unit of foreign exchange. Thus, the criterion of comparative advantage can be put into the quotient $\frac{CDR_i}{v_i}$ in which v_i = the shadow exchange rate.

If the quotient is less than 1, the country has a comparative advantage.

Figure 2

Table of Priorities of Products Using Socio-Economic Criteria *

	1	0_1
	Milk (5.94) Bread (wheat) (3.27) Maize (1.49) Barley Quadrant II	Beef Cattle (9.86) Potatoes (4.55) Rice (3.57) Vegetable Oil (soy, palm, cottonseed, sesame) (3.05) Sugar loaf (2.01) Eggs (1.80) Cocoa (1.71) Quadrant I
1.5		
0_2	Fruit (1.21) Pasta (wheat) (1.09) Beans and Lentils (0.80) Peas (0.80) Plantain (0.74) Cassava (0.61) Oats (0.25) Quadrant III	Cotton Bananas (1.24) Coffee (1.19) Sugar (1.01) Tobacco Flowers Quadrant IV

* Point 0_1 represents the origin for comparative advantage or the quotient between the domestic cost of resources and the shadow exchange rate; point 02 represents the origin for the product's participation in family spending and is measured vertically. This participation or share of spending is shown in parenthesis and represents the structure of spending for blue collar workers in the city of Bogotá. For the time being, comparative advantages are positioned subjectively and will remain so until the corresponding calculations have been done. Another way of situating along the vertical axis would use the quotient Domestic Production and Consumption with a dividing line at point 1 on the table. This line would be the "line of self-sufficiency". In this case the point 0_2 will be at the top corner of the matrix.

product's share in the total family budget. 17/

On the basis of these two criteria, it is possible to set up a table of priorities. Comparative advantage will run along the horizontal axis and the importance a product has in family spending runs along the vertical axis (see Figure 2). The products in quadrants I and IV of this figure are those in which the country has comparative advantage, and can export or substitute for imports efficiently. The products in quadrant IV, due to their low position in family spending, are the easiest to export, so quadrant IV contains exportable items. The products in quadrant I make up a significant part of the consumer shopping basket, besides the comparative advantage the country has in their production. Therefore, quadrant I contains products which could efficiently substitute for imports or could be potentially exported. The products in quadrant II have no comparative advantage but make up a significant part of the consumer shopping basket. The social return on the resources invested in promoting their production is low; this also holds true for the products in quadrant III, whose share of family spending is low. The products in quadrant II are importable or potentially importable. Quadrant III shows importable and domestic products whose share of family spending is not high.

The highest research priority should be given to the products in quadrant I since they have a comparative advantage (the R.S.N. is>0); they are also key items in the counsumer shopping basket. The products in quadrant III have the lowest priority. Government policy definition would provide the information necessary to establish the difference between quadrants II and IV. If the government decides to adopt a policy of promoting exports and obtaining foreign exchange to provide guaranteed supplies of food, quadrant IV would be favored. However, if the government adopts a food self-sufficiency policy, quadrant II is favored. Exporter countries adopting the first type of policy would prefer quadrants I and IV, while self-sufficient countries would choose quadrants I and II.

Furthermore, we must also determine which products should receive priority government financing, and which ones should be left to the initiative of the private sector. This is done by examining the price elasticity of demand. When the demand for a product is inelastic, consumers reap the benefits of research; when the demand is elastic, it is producers who benefit from research. Therefore, the government should finance research on priority products having the least price elasticity of demand and continue up the scale until available resources are exhausted. The research on the other products should be financed by the private sector. Since exportable products usually have a high price elasticity of demand, the products in quadrant IV would be financed by the private sector (coffee, sugar cane, cotton, etc.), whereas the government should handle the products in quadrants I and II. In Colombia, the choice of the products in quadrants I and IV would give products from the tropical zone a clear advantage over those from the Andean zone (except for coffee).

Having set product priorities at the economic level, we then go on to establish technological and research priorities using the method described in section 4 of this paper.

17/ The products that are most difficult to classify are the ones used as raw material in different industrial processes. Some products, like cotton, are especially difficult because they are used in several processes (cotton is used in textiles and cottonseed cake); in such cases, you would have to choose the processes that occupy the most important place in family spending and on the basis of this percentage, estimate cotton's share in this spending.

3.2 Identification of Socio-Economic Priorities in Terms of the Internal and External Market for Agricultural Production

3.2.1 The Concept of Total Value of Agricultural Circulation

The main functions that have been assigned to the agricultural sector in the economic development process were analyzed in section 3.1.1 above. Among these functions, two aspects are of particular importance:

- The satisfaction of the internal demand for food and raw materials needed in the industrial sector (production for the internal market).

- The generation of foreign exchange needed to sustain the development of the national production system, both through agricultural exports and through the substitution of agricultural imports (exports and imports).

These two aspects are of central importance to some of the other functions assigned to this sector, such as the broadening of the domestic market for goods and services produced in the other sectors of the economy, and the liberation of part of the labor force in order to work in non-agricultural activities.

The capacity of the agricultural sector to carry out these functions depends, to a large extent, on the magnitude of the Gross Agricultural Product generated by this sector. It is for this reason that one of the most common indicators to measure the relative importance of every agricultural product, viewed in terms of the function it performs in the whole economy, has been the participation of that product in the total value of agricultural production.

Nevertheless, in order to take into consideration the different functions that have been assigned to the agricultural sector, a more appropriate indicator appears to be the total value generated by the circulation of agricultural products in a given economy, which we will refer to as the total value of agricultural circulation.

The value generated by the circulation of agricultural products has three major components or sources:

- Agricultural production for the internal market (APIM);
- Agricultural exports (X);
- Agricultural imports (M).

The total value of agricultural circulation (AC) is defined as the sum of the value generated by these three components. In other words:

$$AC = APIM + X + M$$

This indicator, which is somewhat different from that of the total value of agricultural production, takes into consideration the three dimensions that were identified above with respect to the main functions assigned to the agricultural sector in the process of economic development. Namely, production for the internal market (satisfaction of the demand for food and raw materials), agricultural exports and agricultural imports. 18/ Table 11 shows the total value of agricultural circulation in Colombia from 1972 to 1976, as well as the annual value of its three components (in constant values of 1970).

The model that is presented in the next section for the identification of socio-economic product priorities, is mainly based on the relative participation of each crop or product in the total value of agricultural circulation.

3.2.2 A Model for the Identification of Product Priorities: Participation in the Total Value of Agricultural Circulation

As it was previously pointed out, the basic premise of this model is that the relative importance of every agricultural product, viewed in terms of the function it performs in the whole economy, can be established on the basis of the participation of that product in the total value of agricultural circulation. A "general priority index" for each crop or agricultural product can be computed through the following procedure:

1) The first step is to determine the total value of agricultural circulation in the country during a given time period. This entails the following:

a) Disaggregation of the total value of agricultural production into its two major components: production for the internal market and agricultural exports. The value of the former is estimated on the basis of producer's prices; the latter is established by converting the FOB value of exports into local currency.

b) The value of agricultural imports (at CIF prices) is converted into local currency, in order to determine the third component that is being measured.

2) Secondly, the relative importance of these three components is established in terms of their percentage participation in the total value of agricultural circulation. This is done not only on the basis of a single year, but on the basis of the average annual value over a number of years, in order to avoid distorsions of exceptional exports or imports

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18/ The total value of agricultural production only reflects the first two components.

Table 11

Colombia: Total Value and Structure of Agricultural Circulation

1972-1976

(in millions of Constant 1970 Pesos)

	1972	1973	1974	1975	1976	Average Value	Weighting Coefficients
Value of production for the internal market	31,186.1	32,047.5	34,908.0	36,472.2	34,276.5	33,778.0	71.6
Value of exports	10,293.7	11,947.4	11,404.8	13,467.5	12,489.4	11,920.6	25.3
Value of imports	741.1	1,332.9	1,906.1	1,183.0	2,040.6	1,440.7	3.1
Total Value of Agricultural Circulation	42,220.9	45,327.8	48,218.9	51,127.7	48,806.5	47,139.3	100.0

Source: Balcazar, Alvaro and Torres Ricardo. Selección de Prioridades Socio-Económicas para la Investigación Agropecuaria. Bogotá, April, 1981, Colciencias, page 79.

in any given year. Thus, in Table 11 we can see the annual values of these three components in the Colombian case from 1972 to 1976, as well as the average annual value of them for this time period. This last information enables us to determine that in Colombia production for the internal market represents 71.6% of the total value of agricultural circulation, while exports represent 25.3% and imports constitute only 3.1% of the total value. These three percentages are used as "weighting coefficients or parameters" in a subsequent step of this method.

3) Thirdly, the percentage participation of each crop or agricultural product in the three components under analysis is determined. This provides information with respect to the relative importance of each product in agricultural production for the internal market, in agricultural exports and in agricultural imports. The corresponding information in the Colombian case can be seen in Tables 12, 13 and 14, for the 1972-1976 period.

4) Finally, the "general priority index" for each crop or agricultural product can be computed as follows:

a) The percentage participation of each crop in the three components of agricultural circulation is multiplied by the relative importance or weight of the respective component in the total value of agricultural circulation. This weighting procedure, that uses the coefficients determined in the second step above, gives us the "weighted participation" of the different crops in the three components of agricultural circulation.

b) The "general priority index" for each crop is computed by simply adding the "weighted coefficients of participation" of that crop in the three components under analysis. It should be pointed out that normally any given crop appears in two of these three components, since it is only under very special circunstances that the same crop is both exported and imported in a specific country.

The procedure that has just been described can be better understood through a concrete example. As can be seen in Table 15, the percentage participation of coffee in the three components of agricultural circulation in Colombia is as follows: in production for the domestic market: 5%; in exports: 73.3%; in imports: 0%. Since the relative weight of each of these three components in the Colombian case is 71.6%, 25.3% and 3.1% respectively, the weighting procedure described above and the general priority index of coffee in this country is as follows:

	Participation %		Weighting Coefficients		Weighted Participation
Production internal market	5.0	x	71.6	=	3.58
Exports	73.3	x	25.3	=	18.54
Imports	0.0	x	3.1	=	0.00
General priority index					22.12

This methodology will be used in the next section to determine the relative priority of 28 agricultural products in Colombia.

Quantitative indicators of relative priorities, such as the one that has just been described, can be effectively used as one of the main criteria in the final decision-making process for resource-allocation, but they should not be considered as the only criteria. At least two other aspects should be taken into consideration. In the first place, as a result of a political decision, and aside from any considerations on social returns, it could be decided to stimulate certain products as part of a national policy of guaranteeing the internal supply of that food crop or raw material. Secondly, an analysis of past production trends and of the future outlook for certain crops, may identify agricultural products with a significant potential importance for the country, although that specific crop may not be of major importance in terms of present levels of production. This may be the case of some of the minor or non-traditional crops in any given country. Thus, the priorities formally established by the method that has been presented should be partially modified or adjusted in the final decision-making process, by considerations such as those that have been mentioned. 19/ Nevertheless this does not invalidate the indicators and the procedure that have been presented, since they do provide a clear basis for decision-making in the process of resource-allocation for agricultural research.

It should also be pointed out that in the application of this model in the Colombian case two additional variables or indicators were taken into account, to see if the model gains in analytical power by substantially modifying the priorities initially identified (see section 3.2.3 below). These two additional variables were rural employment generated by each crop, and the extention of land (area) under that crop's production. No significant modification was introduced by these two additional variables in the priority ranking established by the basic indicators that have been suggested.

A final methodological note is in order with respect to the choice of shadow-prices versus market prices in analyzing the three components of the

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19/ This is quite compatible with the overall framework for the process of identifying research priorities in the agricultural sector that was discussed in section 2.2 above, and summarized in Figure 1 (see upper-half of Figure 1).

total value of agricultural circulation. In the application of this model to the Colombian case market prices were chosen basically for two reasons. In the first place, the price of most agricultural products in Colombia are not substantially distorted by political and institutional action; thus, the difference between market prices and shadow prices is not considered to be significant. If this were not the case, the use of shadow prices might be advisable. Secondly, due to the operational (data gathering) and conceptual difficulties related to the use of shadow prices, it was felt that the additional precision to be gained by their use (in terms of a "different and better" priority ranking) is so marginal, that it does not compensate the additional effort required in data-gathering and data-processing.

One of the greatest operational advantages of the model that has been presented in this section, is that the data it requires is readily available in any country and that its application entails no great difficulty. The observations previously made with respect to the possible need of "adjusting" the priority ranking established by the indicators that have been suggested, on the basis of political considerations or trend analysis, should be kept in mind.

3.2.3 Application of this Model to the Colombian Case

The method for the identification of product priorities for research purposes described in the previous section, was applied to the 28 agricultural products that constitute most of the production of this sector in Colombia. Between 1972 and 1976 the annual average of the total value of agricultural circulation generated by this sector in Colombia was $47,139.3 million Colombian pesos (expressed in constant 1970 pesos). Of this total, production for the internal market represents 71.6%; agricultural exports represent 25.3%; and agricultural imports constitute the other 3.1% (see Table 11). The annual average values over a number of years were used, in order to avoid the distortions that could be introduced by exceptional agricultural exports or imports in any given year.

Following the methodology previously described, the percentage participation of each crop or agricultural product in the three components of the total value of agricultural circulation, was determined. Table 12 shows the percentage participation of the main agricultural products of the country in the agricultural production for the internal market (1972-1976); Tables 13 and 14 show the relevant participation coefficients of these same products with respect to the value of agricultural exports (1972-1978) and agricultural imports (1972-1977), respectively. As in the previous case, an average annual participation rate of the different products, during a given time period, was computed, in order to avoid the distortions that could be introduced by exceptionally high or low crops of a specific product in any given year.

Table 12

Participation of Main Products in the Agricultural Production for the Internal Market: 1972-1976

Products	1972 %	1973 %	1974 %	1975 %	1976 %	Average 1972-76 %
Coffee	5.4	5.0	4.9	3.8	5.7	5.0
Rice	4.8	7.7	8.3	7.0	6.1	6.8
Oats	-	-	-	-	-	
Barley	0.5	0.5	0.5	0.8	0.4	0.5
Maize	4.5	5.0	3.9	3.4	4.3	4.2
Sorghum	1.1	1.6	1.6	1.4	1.7	1.5
Wheat	0.4	0.4	0.4	0.3	0.3	0.4
Potatoe	3.0	3.3	3.3	6.1	4.4	4.0
Plantain	4.9	4.6	4.7	5.9	6.1	5.2
Cassava	7.5	5.4	6.7	7.6	6.1	6.7
Yam	-	0.4	0.3	0.3	0.3	0.3
Sugar Cane	3.2	2.9	2.6	2.4	4.4	3.1
"Panela" *	5.1	5.7	3.7	3.1	7.6	5.0
Soybean	0.8	0.8	1.0	1.4	0.6	0.9
Peanuts	-	-	-	-	-	
African Palm	-	0.8	1.1	0.7	0.7	0.8
Sesame	0.4	0.2	0.3	0.3	0.3	0.3
Cotton	4.7	5.3	5.4	4.0	6.2	5.1
Cocoa	0.7	0.8	0.8	0.7	0.9	0.8
Tobacco	0.5	0.7	0.5	1.1	0.5	0.7
Beans	1.1	0.9	1.1	1.7	1.1	1.2
Bananas	1.0	1.4	1.2	1.0	1.6	1.2
Livestock:						
Dairy	15.4	9.7	9.5	7.4	**	10.5
Beef	**	19.0	16.8	11.8	14.3	15.5
Pigs	5.7	7.2	4.9	6.4	**	6.0
Sheep	0.1	0.1	0.1	0.1	0.1	0.1
Poultry:						
Meat	4.4	4.9	5.2	5.7	**	5.0
Eggs	4.7	5.3	4.8	4.3	4.5	4.7
Others	20.1 ***	0.4	6.4	11.3	21.8***	4.5
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0

Source: Balcazar, Alvaro and Torres, Ricardo. Op. cit., page 75.

* (Sugar Loaf)

** No information

*** The high unexplained percentages in these two years are due to the lack of information, in those particular years, in one or two important products.

Table 13

Participation of Main Products in the Value of Agricultural Exports in Colombia 1972-78

Products	1972 %	1973 %	1974 %	1975 %	1976 %	1977 %	1978 %	Average 1972-78
Coffee	72.9	77.4	73.1	65.7	77.5	81.8	83.0	73.3
Bananas	2.3	2.0	3.0	3.1	3.7	2.5	3.1	2.8
Sugar	4.9	3.9	8.5	9.3	2.2	0.1	0.9	5.8
Cotton	8.7	4.3	5.6	7.4	5.3	6.3	3.0	6.2
Tobacco	1.7	2.0	2.1	1.2	2.3	1.1	1.1	1.9
Rice	0.1	0.1	-	2.0	1.9	1.1	1.1	0.8
Potatoes	-	-	-	0.2	0.1	0.1	0.1	-
Cocoa	-	-	-	-	-	-	-	-
Maize	-	-	-	0.2	-	-	-	-
Beans	0.3	0.3	1.0	0.8	0.5	0.5	-	0.6
Vegetables and Legumes	-	-	-	-	-	-	-	-
Tomatos	-	-	-	-	-	-	-	-
Soybeans	0.1	0.1	-	-	-	-	-	-
Oats	-	-	-	-	-	-	-	-
Flowers	0.5	1.1	1.9	1.9	2.0	1.8	2.2	1.5
Bovines stock	2.3	0.3	0.3	2.6	1.3	0.6	0.6	1.3
Beef Cattle	4.1	5.2	3.8	2.2	1.8	1.3	2.0	3.4
Others	2.1	3.3	0.7	3.4	1.4	2.8	2.9	2.4
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Balcazar, Alvaro and Torres, Ricardo. Op. cit., page 68.

Table 14

Colombia: Participation of Main Products in the Value of

Agricultural Imports: 1972-1977

Products	1972 %	1973 %	1974 %	1975 %	1976 %	1977 %	Average 1972-76
Wheat	67.1	39.4	55.5	60.0	38.0	15.6	52.0
Maize	0.2	11.6	4.3	-	1.3	7.8	3.5
Beans	0.5	0.2	0.2	0.3	-	1.0	0.2
Barley	-	7.5	5.2	2.7	5.7	8.7	4.2
Soybean	2.9	7.4	6.4	-	-	-	3.3
Soybean Oil	0.2	1.0	3.4	2.4	8.4	13.4	3.1
Peas	0.1	1.0	1.2	3.0	1.2	3.2	1.3
Chickpea	0.4	2.8	1.0	-	0.3	0.5	0.9
Lentils	1.8	3.8	3.9	3.4	3.7	3.6	3.3
Apples	5.5	1.8	2.2	3.4	2.8	2.1	3.1
Oats	3.5	2.5	2.0	2.6	1.6	1.6	2.4
Cocoa	12.0	8.8	7.1	6.5	0.3	-	6.9
Beef Cattle	0.1	0.1	0.2	0.2	0.2	0.5	0.1
Dairy Cattle	1.9	1.5	1.4	1.8	4.8	12.0	2.3
Poultry	1.2	0.8	0.5	0.8	0.6	0.6	0.8
Eggs	0.1	-	-	-	-	-	-
Others	2.5	9.8	5.5	12.9	31.1	29.4	12.6
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Balcazar, Alvaro and Torres, Ricardo. Op. cit, page 73.

On the basis of the information provided by Tables 11 through 14, the next step was that of computing the "weighted participation coefficients" of the different agricultural products in the three components of agricultural circulation, and of determining the "general priority index" of each product. The "weighting procedure" described in the preceding section was used to establish these coefficients.

The weighted participation coefficients of the main agricultural products of Colombia are shown in Table 15, as well as the General Priority Index of each product which is derived from the former. As it was previously pointed out, this index measures the relative importance (or participation) of each product in the total value of agricultural circulation in the country, during the time period that is being analyzed (1972-1976). The initial participation rates that appear in Table 15 are really average annual participation rates for this period, which are derived from Tables 12, 13, and 14.

For comparative purposes, Table 15 also includes information with respect to the participation rates of the different crops and products in the total value of agricultural production for this same period (see first column of Table 15). By comparing the first and the last columns of Table 15 we can compare the priority rankings that are established by using participation rates in the total value of agricultural production (first column) and participation rates in the total value of agricultural circulation (last column). The difference between these two priority rankings is greater in those countries or products where agricultural imports play a more important role. 20/ Thus, the difference is greater in products such as wheat in the Colombian case, due to the significant import component for this crop (see Table 15).

Besides establishing a rank order among the 28 agricultural products being considered, the priority index that appears in Table 15 can be used to identify clusters or groups of products, on the basis of which we can classify the different products in terms of general priority levels: "high priority", "medium priority" and "low priority". An analysis of the index that appears in Table 15 clearly identifies four groups of products. 21/

a) Group 1 (index value over 7): coffee, beef cattle and dairy cattle.

20/ The overall importance of agricultural imports in Colombia is not very significant, since it only represents 3.1% of the total value of agricultural circulation.

21/ The index values that are related to these four groups do not represent absolute cutting points in this scale. The groups were established more on the basis of the "clustering" of products and on the distances or differences that appear between them.

Table 15

Weighted Participation Coefficients of Main Products in Total Value of Agricultural Circulation and Computation of General Priority Index

Group	Product	Participation Agr. Produc. Value 1972-76	PARTICIPATION IN: Domestic Market %	Exports %	Imports %	WEIGHTED PARTICIPATION IN: Domestic Market %	Exports %	Imports %	General Priority Index
Group 1	Coffee	15.8	5.0	73.3	-	3.58	18.54	-	22.12
	Beef Cattle*	13.9	15.5	4.7	0.1	11.10	1.19	-	12.29
	Dairy Cattle	8.9	10.5	-	2.3	7.52	-	0.07	7.59
Group 2	Cotton	4.9	5.1	6.2	-	3.65	1.57	-	5.22
	Rice	5.9	6.8	0.8	-	4.87	0.20	-	5.07
	Cassava	5.7	6.7	-	-	4.80	-	-	4.80
	Pigs	5.1	6.0	-	-	4.30	-	-	4.30
Group 3	Plantain	4.5	5.2	-	-	3.72	-	-	3.72
	Sugar Cane	3.2	3.1	5.8	-	2.22	1.47	-	3.69
	Poultry Meat	4.3	5.0	-	0.8	3.58	-	0.02	3.60
	"Panela" (sugar loaf)	4.3	5.0	-	-	3.58	-	-	3.58
	Eggs	4.0	4.7	-	-	3.36	-	-	3.36
	Maize	3.6	4.2	-	3.5	3.01	-	0.11	3.12
	Potatoe	3.5	4.0	-	-	2.86	-	-	2.86
Group 4	Wheat	0.3	0.4	-	52.0	0.29	-	1.61	1.90
	Bananas	1.9	1.2	2.8	-	0.86	0.71	-	1.57
	Sorghum	1.3	1.5	-	-	1.07	-	-	1.07
	Beans	1.2	1.2	0.6	0.2	0.86	0.15	-	1.01
	Tobacco	0.9	0.7	1.9	-	0.50	0.48	-	0.98
	Soybean	0.8	0.9	-	6.4**	0.64	-	0.20	0.84
	Cocoa	0.7	0.8	-	6.9	0.57	-	0.21	0.78
	African Palm	0.7	0.8	-	-	0.57	-	-	0.57
	Barley	0.5	0.5	-	4.2	0.36	-	0.13	0.49
	Yam	0.3	0.3	-	-	0.21	-	-	0.21
	Sesame	0.2	0.3	-	-	0.21	-	-	0.21
	Oats	-	-	-	2.4	-	-	0.07	0.07
	Sheep	-	0.1	-	-	0.07	-	-	0.07
	Peanuts	-	-	-	-	-	-	-	-
	Relative Importance of Components of Agric. Circulation		71.6	25.3	3.1				

* Includes live bovines

** Includes Soybean Oil

Source: Derived from Tables 12, 13 and 14.

b) Group 2 (index value 4 to 7): cotton, rice, cassava and swine production.

c) Group 3 (index value 2 to 4): plantain, sugar cane, poultry, "panela" (sugar loaf), eggs, maize and potatoes.

d) Group 4 (index value under 2): wheat, bananas, sorghum, beans, tobacco, soybean, cocoa, African palm, barley, yam, sesame, oats, sheep and peanuts.

The first two groups are considered to be "high priority" for the country, on the basis of their relative importance in the total value of agricultural circulation. The first group constitutes, in a certain sense, the top priority products. The third and fourth groups represent the "medium priority" and "low priority" products, respectively.

Most of the products in the first three groups are food crops for direct consumption; two of them (cott on and sugar cane) are used as raw materials for the manufacturing industry; and only one of them is basically intended for export (coffee). Most of the foreign exchange produced by the export of agricultural products comes from crops in the first three priority groups.

Since the variables that have been used in this model are basically production variables (i.e., production for the internal market, agricultural exports and agricultural imports), two additional indicators were taken into account to see if they improved the analytical power of the model by substantially modifying the priority ranking established by the initial set of variables. The two additional variables considered were rural employment generated by each crop and the extension of land (area) under that crop's production. 22/

Table 16 compares the participation rates of the different crops in the total value of agricultural circulation (general priority index), with their relative importance in terms of the other two variables. Very few agricultural products undergo a change in their priority ranking important enough to warrant a reclassification in terms of general priority levels. As can be seen in Table 16, only three products (plantain, maize and "panela") shift from medium priority (group 3) to high priority (groups 1 and 2). Plantain and maize increase substantially in terms of both additional variables. The importance of "panela" (sugar loaf) is enhanced mainly by the employment it generates in the agricultural sector. The high ranking of maize in terms of the area under that crop's production should be interpreted with some reservation, since the greater part of

22/ Rural employment generation is measured by multiplying the number of hectares under a given crop's production, by the number of man-days of labor that are employed by hectare. These are estimates published by the Ministry of Agriculture.

Table 16

Comparison of the General Priority
Index Based on Agricultural Circulation with Participation in Area Under
Agricultural Production and Employment Generation

	Products	General Priority Index based on Agricultural Circulation	Participation in Area under Agric. Production	Participation in Employment Generated by Agric. Sector
Group 1	Coffee	22.12	26.6	17.2
	Beef Cattle	12.29	*	-
	Dairy Cattle	7.59	*	-
Group 2	Cotton	5.22	7.0	7.3
	Rice	5.07	9.6	5.9
	Cassava	4.80	5.8	10.2
	Pigs	4.30	-	-
Group 3	Plantain	3.72	9.5	9.9
	Sugar Cane	3.69	2.1	2.9
	Poultry	3.60	-	-
	"Panela" (Sugar Loaf)	3.58	4.6	9.6
	Eggs	3.36	-	-
	Maize	3.12	15.6	12.2
	Potatoes	2.86	3.3	6.4
Group 4	Wheat	1.90	0.8	0.4
	Bananas	1.57	0.5	1.5
	Sorghum	1.07	4.7	0.8
	Beans	1.01	2.8	2.2
	Tobacco	0.98	0.8	7.1
	Soybean	0.84	1.6	0.8
	Cocoa	0.78	1.5	3.2
	African Palm	0.57	0.5	0.9
	Barley	0.49	1.7	0.3
	Yam	0.21	0.3	0.7
	Sesame	0.21	0.8	0.4
	Oats	0.07	-	-
	Sheep	0.07	-	-
	Peanuts	-	0.1	-
TOTAL			100.0	100.0

* Livestock occopies around 25 millions hectares, which implies that it would still remain in this high priority category in terms of the area under cattle production. Since it is so extensive in land-use, this figure was not included for the determination of these percentages, since it would drastically distort the overall picture.

Source: Balcazar, Alvaro and Torres, Ricardo. Op. cit.

this area is shared with other crops (multiple cropping systems). Thus, the net area that is actually used for maize would be much smaller.

The importance of tobacco increases to some extent in terms of employment generated (from low to medium), but it consistently ranks low in terms of the other two indicators. Thus, it would still remain as low priority.

The preceding analysis clearly shows that only minor modifications in the general priority ranking are introduced by the two additional variables. The overall ordering of products is maintained to a large extent.

4. The Identification of Research Priorities within Selected Products or Problem-Areas

The process for the identification of research priorities within selected products or problem-areas that is described in this section was designed and carried out by the "Instituto Colombiano Agropecuario (ICA)" in 1979 and 1980. The first version of the National Plan for Agricultural Research (Plan Nacional de Investigación Agropecuaria) was published by ICA in January of 1981. A more detailed description and analysis of the methodology that was used in this process is presently being prepared by this institution.

4.1 Main Steps Followed in the Process of Identifying Research Priorities Within Products: A Matrix Approach

As it was pointed out in section 2.3 above, despite the fact that the formal identification of product or problem priorities (first phase) was not yet completed, the decision was taken in the Colombian case to go ahead with the determination of technological requirements and research needs at the product level (second phase of the methodological framework that is being followed). The reasons for this decision, as well as its implications from the point of view of the overall planning process, were discussed in the previously mentioned section.

In order to carry out this second phase of the planning process, the list of 28 agricultural products that the Ministry of Agriculture (OPSA) had elaborated was taken as a point of reference. Since these 28 products represent practically the totality of the agricultural production of the country for which there is information (on production and commercialization), the proposed research programs cover a very wide range of the present agricultural production. 23/

The main steps followed by ICA in the process of identifying research priorities at the product level were the following:

a) Regionalization of the country into "ecologically homogeneous zones".

b) Characterization of each region and analysis of the principal production systems that are found in them.

c) Identification and analysis of the main "technological constraints" that have a negative impact on the production or productivity levels of the different products, under the specific environmental conditions that characterize each region. Thus, the analysis is both product-specific and region-specific.

d) Identification and analysis of potential research topics or issues, that are considered to be important to solve the technological constraints faced by each product in specific regions.

23/ The only major exceptions are coffee and sugar cane, which in the case of Colombia are research areas that are in the hands of the private sector.

The first three steps were carried out through a national survey, on the basis of which a technological profile or technological diagnosis of the agricultural sector was elaborated. 24/ The fourth step was carried out through working groups established for each product, in which the delphic technique was used (based on group discussions) for the identification and analysis of research topics or issues in response to the technological constraints previously identified. The first three steps are described in this section; the fourth one is analyzed in the next section of this paper.

In the first place, the country was divided into "natural regions" and "ecologically homogeneous zones", mainly on the basis of physical parameters that characterize and differentiate each zone. The principal physical parameters that were taken into consideration in regionalizing the country are the following:

a) Climate variables.
b) Water availability (hydrological resources).
c) Types of soil and soil characteristics.
d) Dominant flora and fauna.

Seven main "natural regions" were identified in the country: Caribbean Region, Pacific Region, Andean Region, Inter-Andean Valleys, Orinoquia Region, Amazon Region and Island Territories. Within each natural region, an effort was made to identify sub-regions that could define "ecologically homogeneous zones" of economic importance (in those cases where this was relevant and only for the purpose of a more detailed analysis). These are geographical units which are more homogeneous from the point of view of the above mentioned aspects or parameters.

The second and longest phase of this analysis was the characterization of these natural regions or ecologically homogeneous zones. This characterization covers several aspects:

a) Characterization of the physical or environmental parameters mentioned above. For example, climate characteristics were analyzed in terms of:
- Total and monthly precipitation levels (rain),
- Temperature range and monthly variations,
- Relative humidity,
- Sunshine.

The soil characteristics were analyzed in terms of the dominant types of soil and in terms of such parameters as erosion, depth, external drainage,

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24/ See ICA: Sector Agropecuario Colombiano: Diagnóstico Tecnológico (2 volumes), Bogotá, ICA, August, 1980.

fertility (i.e., pH values), salinity and elements that are low or in excess in the types of soil found in that region. The other aspects are characterized by similar parameters that are relevant for each case.

b) Characterization of the socio-economic characteristics of the region. Both economic and social aspects of the agricultural sector in that region are analyzed, such as:

- Agricultural and animal production (both in terms of volume and in terms of its participation in the national agricultural production).
- Regional consumption and regional contribution to the national internal market and to exports.
- Importance of agricultural production in the regional economy.
- Economically active population, rural employment and migration.
- Land tenure structure and relationship with cropping and farming systems.
- Organizations of producers and managerial capacities.

c) Characterization of the agricultural production system in that region. Identification and analysis of the principal agricultural products (both in terms of crops and animal production), and of the principal farming systems and cropping systems that are being used. This leads to an analysis of the interaction between crops, cropping systems and the environmental and socio-economic characteristics of the region, previously identified. Other aspects, such as the degree of mechanization, use of agricultural inputs, labor or capital intensivity, productivity levels of the different crops or animals, energy sources and forms and timing of planting and harvesting activities, are also taken into consideration in order to characterize the type of production technologies utilized.

d) Characterization of the support services that exist in the region. This refers to such services as technical assistance, credit facilities, commercialization mechanisms, supply of agricultural inputs, transportation facilities, training institutions and other support services.

The third step plays a central role in this process of identifying research priorities at the product level, since it is related to the identification and analysis of the main "technological constraints" that have a negative impact on the production or productivity levels of the different products under consideration. In order to do this, it was first necessary to identify the principal technological factors that intervene in the production process, both in the case of crops and in the case of animal production.

In the case of crops, the principal technological factors were conceived in terms of eight categories, each one related to a specific discipline of the agronomy sciences. These eight technological factors (and disciplines) are the following:

Technological Factors:	Disciplines:
1) Farming practices (including cropping systems).	1) Farming practices.
2) Production equipment: agricultural machinery and implements.	2) Agricultural machinery.
3) Knowledge on plant genetics, and on the development of desirable genotypes and their seeds.	3) Plant genetic improvement ("Fitomejoramiento").
4) Knowledge on insects, rodents and moluscs, on their impact in crops, and on control methods.	4) Entomology.
5) Knowledge on plant diseases, on disease-causing agents (bacteria, virus, fungi) and on their control.	5) Plant pathology.
6) Knowledge on plant physiology, in order to improve their efficiency (yield) or to control them (weeds).	6) Plant physiology.
7) Soil as a factor of production; knowledge on soils: their characteristics, improvement and conservation.	7) Soil sciences.
8) Water as a factor of production: knowledge on hydrological resources and on water management and distribution (irrigation).	8) Water and irrigation.

In the case of animal production, the following six technological factors (and disciplines) were considered:

Technological Factors:	Disciplines:
1) Knowledge on animal production systems and techniques.	1) Animal production.
2) Knowledge on animal physiology and reproduction.	2) Animal physiology and reproduction.

Technological Factors:	Disciplines:
3) Knowledge on animal genetics and on cross breeding.	3) Animal genetics.
4) Animal food and feeding systems; nutrition problems.	4) Animal food and nutrition.
5) Pasture and forage as a factor of production.	5) Pasture and forage.
6) Knowledge on animal diseases, their causes and their control.	6) Animal health.

In each region, an effort was made to identify and analyze the main "technological constraints" that have a negative impact on the production or productivity levels of the principal products (crops and animals), under the specific environmental conditions that characterize that region. These technological constraints were identified by analyzing the situation of each of the above mentioned technological factors (either for crops or for animals), as well as the impact of specific problems or bottlenecks identified in them on production or productivity levels. Thus, technological constraints were expressed in terms of limitations, deficiencies or problems related to one of these technological factors, that were responsible for low production or productivity levels (i.e., certain crops in a given ecological region or zone might be facing soil deficiency problems, or might show specially low yields or particularly high vulnerability to diseases; or an important bottleneck for animal production in certain regions might be found in poor pastures or in inefficient animal production systems). These technological constraints lead to the identification of research needs and of specific technological requirements (such as technical assistance), at the level of each product in given geographical regions (ecological zones) of the country.

The first three steps that have just been described in the process followed by ICA for the identification of research priorities at the product level, define an analytical matrix that permits us to relate different agricultural products to specific technological constraints, under certain environmental conditions that define ecologically homogeneous zones (see Figure 3). Each cell of the matrix that appears in Figure 3 defines a potential research area or topic, in order to solve a specific technological constraint (production problem) that is limiting the productivity level of a given agricultural product, within an identifiable region or ecological zone.

It should be pointed out that the same product may face different technological constraints, in different geographical or ecological regions. For example, in a given region the crop under consideration may face a serious problem of soil deficiency, while in other regions the main problem may be a high vulnerability to diseases, despite relatively good soils. Furthermore, the importance of

Figure 3.

Matrix Approach to Research Planning in Agricultural Research*

Principal products considered to be of high socio-economic importance or priority for the country:	Principal Technological Constraints and Ecologically Homogeneous Zones									
	Technological Constraint - 1			Technological Constraint -2			Etc.	Technological Constraint - i		
	EHZ-1	EHZ-2	EHZ-i	EHZ-1	EHZ-2	EHZ-i		EHZ-1	EHZ-2	EHZ-i
Product - 1										
Product - 2					α / β					
Etc.										
Product - i										

Notes: a) EHZ refers to the different Ecologically Homogeneous Zones.

b) " α " stands for the importance of a given technological constraint, for a specific agricultural product, in a specified ecological zone or region.

c) " β " stands for the importance of the existing pool of knowledge and technological know-how that may be used in the solution of that specific technological constraint.

* This is an adapted version of the matrix that is presented by ICA in the first volume of the Plan. See ICA: Plan Nacional de Investigación Agropecuaria del ICA, Bogotá, Volume I, 1981. Instead of "α" and "β", ICA uses the symbols "L" and "O" based on the Spanish words for these two concepts("Limitantes Tecnológicos" and "Oferta Tecnológica").

a given technological constraint may vary from one region to another, for the same agricultural product. Thus, the analysis of technological constraints is both product-specific and region-specific, although some of them may cut across several regions.

Finally, it should also be pointed out that not all cells of the matrix are relevant, either because not all products are found in all the ecological regions, or because a given technological constraint may not be relevant or important for all agricultural products (see Figure 3). The importance of each matrix cell (each research topic), depends both on the relative importance of the product, and on the magnitude (difficulty) and importance of the technological constraint to be solved.

The main output of these first three steps in the process of defining research priorities at the product level, is the identification and description (diagnosis) of important technological constraints, that limit production or productivity levels of specific agricultural products in certain ecological regions. 25/ Further analysis of the importance of each research area (cell of the matrix), as well as the disaggregation of each area into more specific research topics (potential research projects), was carried out in the fourth and last step of this process, which is described in the next section.

4.2 The Use of the Delphic Technique for the Identification of Technological Requirements and Research Needs

Having determined the principal technological constraints that limit the production or productivity levels of specific crops in certain ecological regions, the next step of the process was that of deriving from them research needs (and therefore research priorities). This implies a dissagregation of each matrix cell of Figure 3 into research topics or projects that may contribute to the solution of each technological constraint.

In order to do this, special working groups were established in the different products and problem-areas that were being considered. Each working group was made up by a group of experts with a long experience in that specific product and research area, and with a good knowledge of the agricultural sector in the country and the production problems it faces.

These groups basically used the "Delphic" technique, by having a group or panel discussion on the technological constraints under consideration, with the purpose of arriving to a consensus on the different aspects involved in each technological bottleneck and on the research topics or projects that could contribute to

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25/ In the Colombian case this is presented in ICA: Sector Agropecuario Colombiano: Diagnóstico Tecnológico (2 volumes), Bogotá, ICA, August, 1980.

the solution of those problems. This technique has been widely used in many countries, both in the identification of research needs and priorities, and in technological assessment (analysis of future technological developments and their impact). 26/

In this analysis, each group took into consideration the three major aspects that were identified in Figure 1 (see section 2.2), as components of the general methodological framework for the identification of research priorities:

a) The technological constraints that have a negative impact on the production or productivity levels of specific agricultural products, under the environmental conditions that characterize a given geographical region (demand of technology).

b) The pool of existing knowledge, know-how and technologies (in the country or abroad), that is already available and that could be used to solve that specific technological constraint (supply of technology).

c) The desirable characteristics of technological change that one wishes to promote in the agricultural sector (desirable technological path). This provides criteria that may be used to evaluate technological alternatives, when they exist, or to design new technologies through research efforts.

The importance of the second factor is quite evident. In some cases, a technological constraint may be identified in a given product, despite the fact that there is technological know-how already available, that could be used to solve the production problem under consideration. In such a case the problem is one of transfer of technology to the producer, and not of development of new technologies through research programs.

Each group, whose attention always centered in a specific product, had at its disposal three main inputs as a starting point for their deliberations:

a) The technological diagnosis of the agricultural sector that was elaborated in the previous steps of this process (see section 4.1). This diagnosis analyzes the production problems of the different crops, identifies major technological constraints and has a preliminary evaluation of the importance of each constraint.

26/ For a discussion of the use of the Delphi methodology and of matrix techniques in this type of analysis, see Marvin J. Cetron and Bodo Bartocha: The Methodology of Technology Assessment. New York, Gordon and Breach Science Publishers, 1972.

b) Brief "state-of-the-art" reports were prepared for each product (and thus for each group), summarizing the present research effort and the principal available technologies developed for that product. The objective of these reports was to have an approximate idea of the pool of existing know-how and technologies relating to the product under consideration.

c) The knowledge and experience each participant brought to the group. Given the importance of this factor, the selection of the group members is of crucial importance in this Delphi methodology.

The discussions of the working groups as such centered around two main issues:

a) Analysis of the real importance and nature of each of the technological constraints that are confronted (each relevant matrix cell in Figure 3 above).

b) Identification of research projects that should be carried out, in order to generate the knowledge or know-how that is needed for the solution, elimination or drastic reduction of that technological constraint.

With respect to the first main issue raised, the importance and nature of the technological constraint under consideration was analyzed by comparing two indicators:

- The importance of the technological constraint that is being faced, from the point of view of its impact on production or productivity levels (α).
- The importance or amount of the existing know-how that could be used effectively to solve or reduce the technological constraint (β).

The magnitude of these two indicators was "measured" in terms of an integral scale ranging in value from 1 to 10. In this scale, 1 represents a technological constraint of very low importance (impact), and a very low or limited technology supply. Ten represents a very important technological constraint (strong impact), and a highly important supply of technology that could be used to control or diminish the technological constraint under consideration. In both instances 5 represents an intermediate situation. The values given to each technological constraint with respect to these two indicators, were determined by each group (group discussion technique), on the basis of the three sources of information available to them.

In terms of the analytical matrix that is presented in Figure 3, every relevant matrix cell (each technological constraint identified) has these two values (see Figure 3).

The range of points in both scales was divided into the following three categories:

- 1 - 3 : Low
- 4 - 6 : Medium
- 7 - 10 : High

These three categories were used in the subsequent applications of these two indicators.

The comparison between the two indicators (α/β) in the case of each technological constraint was used to determine the importance or priority of that constraint, as well as some indication as to the nature of the technological problem faced. The different possible combinations of the comparison between the two indicators (α/β) was used to classify all identified technological constraints into three levels of priority (high, medium and low), according to the relationship between the perceived importance of the technological constraint (α), and the present availability (supply) of know-how and technologies that could be used to control or diminish that constraint (β). The different possible combinations of this relationship (α/β), and their interpretation for assigning an overall level of priority to each technological constraint (matrix cell), is as follows:

a) $\frac{\text{Medium}}{\text{Low}}$, $\frac{\text{High}}{\text{Low}}$, $\frac{\text{High}}{\text{Medium}}$: High Priority

b) $\frac{\text{Low}}{\text{Low}}$, $\frac{\text{Medium}}{\text{Medium}}$, $\frac{\text{High}}{\text{High}}$: Medium Priority

c) $\frac{\text{Low}}{\text{Medium}}$, $\frac{\text{Low}}{\text{High}}$, $\frac{\text{Medium}}{\text{High}}$: Low Priority

An effort of formulating research needs and research projects (the next step of the process) was done only for those technological constraints with high and medium priority levels. Low priority technological constraints were disregarded, except in those cases where a certain ongoing research level was considered necessary to maintain a technology previously developed.

In certain cases, an analysis of the relationship between these two indicators (α/β) gives some insight into the nature of the technological problem that is being confronted. When the case is that of a highly important technological constraint, with a low availability or supply of technological know-how to cope with that problem, there is obviously a need of a research effort to develop the necessary technology. But when we confront a situation of a highly important technological constraint (i.e., seriously limiting production or productivity levels), on the one hand, and the existence or availability of an important (high) or moderately important (medium) body of knowledge or of usable technology to solve that constraint, the technological problem confronted is not basically a research problem (lack of knowledge).

In such a situation we are confronted by the fact that the technologies that have been developed in the agricultural research stations (in the country or abroad) are not being used by the producers. Two major factors can explain this situation. In the first place, this may reflect a problem of inefficient agricultural extension and technology transfer to the producer. Thus, the technological requirement generated in this situation is not for more research, but for better technology transfer mechanisms (technical assistance, credit, etc.).

Secondly, this situation may also be partly due to the fact that the technology that has been developed (existing supply) is not the most appropriate one for the type or characteristics of the producers for which it was developed. For example, the cost of the agricultural input (i.e., fertilizers) necessary to use that technology may be too high for the type of producer that should be using it, or the degree of mechanization or scale of production that are required do not correspond to the characteristics or capacity of the latter. In such a case we would either have to modify the conditions and characteristics of the producers themselves, or develop alternative technologies more adapted to the production conditions existing in the country (research requirement).

These two examples clearly show that an analysis of the relationship between these two indicators (α/β) in each technological constraint, may give important insights as to the nature of the technological problem that is confronted. Moreover, it also points out that not all technological requirements lead to research needs. They may also define problems of technological information and technical assistance, or problems of diffusion and adoption of technologies.

The last step in this planning process was the identification and formulation of research topics or research projects, that are considered important in order to control or diminish the production problem that is faced. As pointed out earlier, this last exercise was carried out only for those technological constraints that were considered to be of high or medium priority, on the basis of the previous analysis. The research projects were identified and defined by each working group, using the relevant information and inputs they had at their disposal. The group discussion technique and the expert advice provided by group members, were used as a means for arriving to a consensus with respect to the research projects.

The outcome of this process was the formulation of a set of research projects for each agricultural product, aimed at solving or controlling the principal technological constraints that were identified with respect to that product. The different research programs thus formulated constitute the National Agricultural Research Plan recently presented in its first version. 27/

4.3 Some Observations with Respect to the National Agricultural Research Plan

Using the ICA methodology that has been described, a first version of the National Agricultural Research Plan of this Institute has been formulated in Colombia. The Plan covers four main areas:

a) Agricultural research

b) Animal science research

c) Research on rural socio-economic development

d) Research on rural communication

The two first areas are by far the most important components.

Each area is made up by a number of research programs, the latter being each one constituted by a set of research projects. Not all research programs are formulated at the level of agricultural products. Some of them refer to the technological factors that were identified in the production of crop and animals, and to the agronomy disciplines that are related to them. 28/

A total of 63 research programs were formulated with the following distribution in terms of the four areas previously mentioned (the list of these programs is included in Annex I):

a) Agricultural research: 33 research programs, 25 of which are in terms of crops and 8 in terms of disciplines or factors of production. It should be pointed out that a research program on cropping systems was included, as part of the 25 programs in terms of crops.

b) Animal science research: 14 research programs, 8 of which are in terms of animal species and 6 in terms of factors of production.

c) Research on rural socio-economic development. Formal research programs were not formulated in this area as in the previous ones. But 11 research topics were identified as being of high priority for the understanding

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27/ See ICA: Plan Nacional de Investigación Agropecuaria. Bogotá, ICA, January, 1981 (5 volumes).

28/ For a description of "technological factors" in these two instances, and of the relationship between technological factors and technological constraints, see section 4.1 in this paper.

of rural socio-economic development, and as a support to the technological development programs.

d) Research on rural communication: 5 areas of research were identified in terms of the principal social actors or social groups that intervene in the process of rural communication. The objective here is to determine the characteristics and information needs of different types of users, the relative efficiency of different communication media, and the role of rural communication in the process of technology transfer.

The projects that are formulated within each research program are region-specific, in terms of the geographical regions into which the country was divided. For example, the 33 research programs of the agricultural area are constituted by a total of 638 research projects. These, in turn, are distributed among the different geographical regions as follows:

- Andean Region:	506 projects
- Inter-Andean Valleys:	414 projects
- Caribbean Region:	386 projects
- Orinoquia:	125 projects
- Pacific Region:	25 projects

It should be pointed out that a given research project can be related to two or more regions, according to the distribution and importance of a crop or a technological problem in the different regions of the country.

The large number of research programs and the wide distribution of topics and research areas, is one of the present problems or limitations of the first draft that has been elaborated of the National Agricultural Research Plan. This is due to the fact that the first phase of the planning methodology described above, has not been completed (for a discussion of the reasons and the implications of this, see section 2.3 above). As it was previously pointed out, the formulation of research programs at the product level (second phase) was carried out practically for all agricultural products, and not only for those that are considered to be of high priority for the country (see section 2.3 in this paper).

Thus, although research priorities have been validly assigned <u>within</u> products or technological factors of production (second phase), this effort is still missing at the inter-product level, on the basis of socio-economic priorities for research purposes (first phase). The consequence of this is the large number and wide distribution of research programs that characterizes the present version of the research plan.

The last step of this planning process in the Colombian case will be the completion of the first phase of the methodology that has been described, using one or both of the analytical models discussed in section 3 of this paper. This will presumably narrow down both the number and the wide distribution of the research programs that will finally be included in the National Agricultural Research Plan.

ANNEX I. Research Programs that were Formulated as Part of the National Plan for Agricultural Research

A. Agricultural Research Area:*

a. Research Programs on Agricultural Crops:

1. Sesame
2. Cotton
3. Rice
4. Peas
5. Oats for Forage
6. Cocoa
7. Sugar Loaf (Panela)
8. Barley for Malt
9. Barley for Human Feed
10. Coconut
11. Cropping Systems
12. Beans
13. Fruits
14. Vegetables
15. Peanuts
16. Maize
17. Yam
18. African Palm
19. Potatoes
20. Plantain
21. Sorghum
22. Soybean
23. Tobacco
24. Wheat
25. Cassava

b. Research Programs on Factors of Production:

26. Entomology
27. Plant Physiology
28. Phytopathology
29. Plant Breeding
30. Soils

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* This does not include two major research areas (coffee and sugar cane), since in the Colombian case these two research areas are in the hands of the private sector.

31. Water and Soil Resources
32. Farm Process
33. Form Machinery

B. Animal Science Research Area:

a. Research Programs on Animal Species:

1. Dairy Beef Cattle
2. Specialized Dairy Cattle
3. Beef Cattle
4. Poultry
5. Swine
6. Sheep
7. Rabbit
8. Bees

b. Research Programs on Factors of Production:

9. Physiology and Reproduction
10. Nutrition
11. Animal Production
12. Pasture and Forage
13. Animal Health
14. Animal Genetic

C. Research on Rural Socio-Economic Development:

1. Technology Economic Analysis
2. Socio-Economic Factors Determining the Adoption of Technology
3. Production Costs and Factors Retribution
4. Rural Employment
5. Formation and Functioning of Capital
6. Administration
7. Demand and Supply Studies
8. Product Marketing
9. Inputs Marketing
10. Land Size and Tenure
11. Types of Guild Organizations

D. Research on Rural Communication:

1. Large Producers
2. Private Technical Extension Workers
3. Institutions Related to Formal and Non-Formal Education in the Rural Sector
4. Change Agents
5. Small Farmers

República de Colombia

DEPARTAMENTO NACIONAL DE PLANEACION

BASES PARA EL PLAN NACIONAL DE INVESTIGACIONES DEL SECTOR AGROPECUARIO, FORESTAL Y PESQUERO

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Miembros del Consejo Nacional
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BASES PARA EL PLAN NACIONAL DE INVESTIGACIONES DEL SECTOR AGROPECUARIO, FORESTAL Y PESQUERO

I. INTRODUCCION

La política agropecuaria, forestal y pesquera planteada en el Plan de Integración Nacional reconoce que una de las estrategias fundamentales para acelerar el crecimiento del sector es la de incrementar la productividad de los factores de producción utilizados en el área rural. Entre las medidas de política que contribuyen a este incremento de la productividad se encuentra, primero que todo, el apoyo a la investigación. Esta, de acuerdo con lo señalado en el PIN, ha encontrado obstáculos por la carencia de políticas claras en el mediano y largo plazo, así como en la falta de fondos adecuados para impulsarla.

Dentro de esto marco, el objetivo del presente documento es el de plantear los lineamientos generales que conduzcan a la definición de una política tecnológica para el sector agrario y especificar los términos en que se deben crear el Consejo Nacional de Investigaciones y Desarrollo Tecnológico Agrario y el Fondo Nacional de Investigaciones y Desarrollo Tecnológico Agrario, propuestos en el PIN como elementos fundamentales para promover y encauzar la investigación en el sector agropecuario.

II. RESUMEN DEL DIAGNOSTICO

La investigación agropecuaria, forestal y pesquera en Colombia reviste características particulares por cuanto hay marcadas diferencias entre regiones, productos y tipos de productores, lo cual no ha permitido en muchos casos una aplicación generalizada, a los diferentes cultivos y especies, de las innovaciones tecnológicas.

En Colombia ha tenido lugar, a raíz de la llamada revolución verde, un considerable avance en materia de productividad agraria en los últimos decenios. Sin embargo, se ha detectado un amplio margen para continuar el avance en materia de investigación agropecuaria para casi todos los cultivos, en especial en el desarrollo y adaptación de tecnologías adecuadas y en la producción de variedades mejoradas y de razas más productivas.

A. INVESTIGACION AGROPECUARIA

El país ha obtenido resultados satisfactorios mediante la generación de nuevas variedades que, además de ofrecer altos rendimientos, tienen un período vegetativo más corto. Cabe destacar que hacia finales de 1979 el ICA había producido un total de 205 híbridos y variedades en 31 cultivos diferentes, entre los cuales se destacan los logrados en banano, cacao, cebada, fríjol, caraota, maíz, sorgo y trigo. A pesar de que se han logrado avances innegables, los rendimientos aún permanecen a niveles bajos en comparación con los obtenidos por nuestros competidores en los mercados externos.

Los cultivos asociados a zonas de minifundio muestran una mayor brecha tecnológica y por tanto presentan una amplia potencialidad aparente, destacándose los casos del maíz, el trigo, la papa y el fríjol. En los casos del arroz y la soya, cuyos rendimientos están entre los más altos de América Latina, existe todavía un potencial de mejoramiento si se les compara con los observados en el contexto mundial.

La brecha de productividad anteriormente señalada hace pensar que los servicios de asistencia técnica no tienen el suficiente impacto. En efecto, este servicio cubre apenas un 34% del área cultivada, con énfasis en arroz, algodón, soya, maíz y papa y con una alta concentración en las zonas DRI.

En relación a la ganadería, la productividad ha permanecido estancada, muy por debajo de los niveles de eficiencia posibles. La brecha tecnológica en la producción de carne es bastante amplia y entre las limitantes tecnológicas se destacan los aspectos que tienen que ver con la alimentación, el manejo, la sanidad y el mejoramiento genético.

B. INVESTIGACION FORESTAL Y PESQUERA

En el campo de la silvicultura se han logrado algunos avances en el planeamiento y mejoramiento genético, aunque éstos se han limitado a un número reducido de especies. En los últimos años se han iniciado programas de investigación y ya se comienza a hablar de la actividad agrosilvipastoril, o sea la combinación del establecimiento de bosques con cultivos agrícolas y actividades pecuarias. Estos programas son la base para desarrollar sistemas tecnológicos adecuados a las actuales áreas de colonización y zonas minifundistas de vocación forestal.

Con contadas excepciones, no se ha hecho investigación en el manejo de los bosques naturales y los pocos trabajos existentes son en su mayoría de carácter descriptivo. Por su parte, los actuales sistemas de aprovechamiento son notoriamente ineficientes ya que se desperdicia más de un 35% del volumen maderable y se dejan de explotar numerosas especies por desconocimiento de sus posibilidades de utilización.

Cabe destacar que la investigación forestal se caracteriza por el largo plazo de su maduración y que por lo tanto requiere de continuidad no siempre encontrada en el actual sistema institucional.

En relación al subsector pesquero, la investigación es definitivamente escasa, siendo prioritario obtener un conocimiento más preciso del recurso en cuanto a su ubicación y cuantificación. Así mismo, el sistema de pesca artesanal es de muy bajo nivel tecnológico, y en él predominan patrones tradicionales en las artes y metodologías de pesca, evidenciándose el requerimiento de un proceso acelerado de transferencia de tecnología. Tal situación es generalizada y aún en el caso de la pesca industrial se tiene un nivel de adopción tecnológica muy bajo a pesar de que se dispone de algunas técnicas modernas.

C. ASPECTOS INSTITUCIONALES

La revitalización de la investigación agropecuaria requiere de una reorientación institucional, sobre todo a nivel del aparato estatal, con el fin de coordinar y concertar las acciones que adelanta el país en materia de desarrollo tecnológico.

Desde el punto de vista institucional, merecen destacarse dos aspectos principales. En primer lugar, aproximadamente el 80% de la investigación en Colombia la efectúa el ICA. En segundo lugar, no se ha contado con el necesario señalamiento de prioridades para distribuír los pocos recursos disponibles para la investigación y la transferencia de tecnología en el sector agrario. En general, la determinación de prioridades ha dependido principalmente de situaciones coyunturales y la necesidad de obtener resultados a corto plazo ha impuesto un criterio inmediatista en la toma de decisiones.

1. Papel del ICA, INDERENA y CONIF

Durante la última década se han venido asignando al ICA funciones diferentes a las de investigación, extensión y docencia que le son propias. Tal es el caso de las labores de fomento a la producción que se relacionan con las campañas sanitarias, la asistencia técnica y la colocación de crédito; las actividades de control que tienen que ver con la certificación de semillas y supervisión de insumos y otras acciones como las construcciones rurales, la microinfraestructura y la sanidad portuaria.

El ICA es el único instituto de investigación en América Latina que tiene a su cargo labores administrativas como las mencionadas. La diversidad de sus funciones, la competencia interna por recursos que tiene lugar entre ellas, y la ineficiencia generada por estos factores, hacen pensar que el actual modelo institucional es inapropiado.

Las funciones adicionales han implicado mayores presiones sobre los recursos de la institución puesto que ellas no han venido acompañadas de los correspondientes aportes en el presupuesto nacional, los cuales se han mantenido dentro del mismo orden de magnitud en términos reales. Esto ha obligado al Instituto a distraer sus esfuerzos hacia la búsqueda de mayores recursos propios, labores que compiten en términos de recursos humanos y financieros con las actividades científicas de la institución.

Además de la escasez de recursos disponibles para el INDERENA y CONIF, a través del tiempo, para la investigación forestal, la labor del primero de ellos ha evidenciado falta de continuidad, debilitando así el liderazgo que debe ejercer. En este instituto también se ha desarrollado la dualidad entre las funciones de control, vigilancia y fomento, por un lado, y la labor de investigación y extensión, por el otro, siendo por ello cuestionable la actual estructura institucional.

2. Prioridades de la Investigación

La inexistencia de un esquema general que defina las prioridades a nivel nacional y que consolide la información sobre las investigaciones que se están realizando y que se pretenden realizar, ha llevado a que tenga lugar una duplicidad de esfuerzos, una disparidad de criterios y una baja utilización de la capacidad instalada. Tal situación sugiere que los recursos de origen estatal deben ser asignados a la luz de las prioridades de los Planes de Desarrollo sin que por ello se entorpezca la actividad investigativa de quienes desearían realizarla con sus propios medios. En efecto, en el último decenio, paralelo al proceso de estancamiento de la investigación oficial, se ha producido un favorable desarrollo de la investigación llevada a cabo por el sector privado.

III. OBJETIVOS

A. OBJETIVOS GENERALES

El objetivo prioritario del Plan es el desarrollo y la provisión de tecnología apropiada que promueva el cambio tecnológico y mejore la productividad de los recursos empleados en el sector rural, con el fín de reforzar el abastecimiento de alimentos y materias primas a precios competitivos. Adicionalmente, la investigación debe estimular la generación de una oferta exportable creciente que permita aprovechar al máximo las oportunidades del mercado internacional y coadyuvar, así, al mejoramiento de los ingresos reales del productor en forma tal que auspicie su permanencia en el agro.

En segundo lugar, el plan debe suministrar elementos para racionalizar y canalizar la inversión pública y privada en el área de investigación, definiendo criterios para seleccionar los proyectos prioritarios del sector, de forma tal que se incremente la tasa de rentabilidad social de esta actividad.

B. OBJETIVOS ESPECIFICOS

Se persiguen los siguientes objetivos específicos:

1. Proponer un esquema para establecer las prioridades para la investigación agropecuaria, forestal y pesquera, tanto de corto como de largo plazo, que partiendo de criterios socioeconómicos y tecnológicos, permita hacer un uso eficiente de los recursos disponibles para esta actividad.

2. Diseñar un Sistema Nacional de Investigaciones agropecuarias, forestales y pesqueras que integre en forma coordinada los esfuerzos de las entidades nacionales e internacionales, públicas y privadas, y los oriente hacia objetivos comunes en este campo dentro del marco de la política sectorial.

3. Proponer las reformas institucionales y las políticas relacionadas que sea necesario adelantar con el fin de adecuar la estructura técnico-administrativa de las entidades oficiales que hacen parte del sistema nacional de investigaciones.

4. Proponer una política de recursos humanos para la investigación en el sector agrario que contemple mecanismos de capacitación y formas de remuneración acordes con la condición del investigador.

5. Diseñar mecanismos de coordinación y financiación para la ejecución y evaluación de los proyectos de investigación y para la captación de recursos financieros en forma contínua.

IV. LINEAMIENTOS GENERALES DE UNA POLITICA TECNOLOGICA AGRARIA

Como resultado del diagnóstico, se sugieren una serie de lineamientos básicos que encaucen la acción de las entidades dedicadas a la investigación y a la transferencia de tecnología en el sector.

El criterio fundamental, especialmente para las entidades estatales, consiste en que la investigación tecnológica debe seguir una línea de política que consulte principalmente metas de tipo socio-económico. Para un país en desarrollo como Colombia, el gasto en investigación es una inversión de la cual hay que obtener el mayor provecho, tanto desde el punto de vista de los beneficios privados que acompañan a los aumentos en productividad, como desde el punto de vista del beneficio social que se obtiene de ésta. En esa forma, las metas del Plan Nacional de Ciencia y Tecnología deben derivarse de las políticas del plan de desarrollo.

La traducción de los objetivos del desarrollo social y económico en directrices para la investigación tiene en la selección de prioridades un instrumento fundamental. A pesar de los limitados recursos de que actualmente dispone la investigación, éstase caracteriza por una amplia dispersión debido a la excesiva cantidad de productos y temas de los que se ocupa. Con la selección se trata de orientar ordenadamente gran parte de los escasos recursos disponibles hacia los productos de mayor significación socio-económica relativa, sin descuidar las labores correspondientes a los demás. Con ello se trata de asegurar una mayor efectividad en la obtención de resultados significativos desde el punto de vista de la producción nacional.

En cuanto a los productos identificados, cada uno de ellos tiene su propia problemática tecnológica, en términos de limitantes, del grado de esos limitantes y del esfuerzo que es necesario realizar para superarlos. La determinación de prioridades de investigación, entonces resulta de la confrontación de dos aspectos: el socio-económico, que evalúa la importancia de cada producto e interpreta las políticas de desarrollo y, el tecnológico, que estudia el carácter y la magnitud de los limitantes que lo afectan. En este sentido, el aspecto tecnológico debe ser lo suficientemente amplio y flexible como para permitir su confrontación con el factor socio-económico y de esta forma obtener una visión global de las prioridades.

Por otro lado, la problemática tecnológica y socio-económica de la producción agraria está determinada, en gran parte, por las particularidades de su localización regional. Por lo tanto, la programación de la investigación deberá tener en cuanto los aspectos de regionalización, tanto en la fase de diagnóstico como en la fase de ejecución, pues el país se encuentra dividido en grandes regiones naturales, dentro de cada una de las cuales existen zonas agroecológicas homogéneas. La identificación y caracterización de éstas permitirá una asignación más eficiente de los recursos de investigación y también el desarrollo del proceso multiplicador de los resultados.

La investigación agraria no debe limitarse a los aspectos biológicos o a la producción de variedades mejoradas sino que debe tener en cuenta otras fases del proceso agrario, en especial lo referente a las técnicas de manejo posteriores a la cosecha con el objeto de minimizar las cuantiosas pérdidas físicas en esta etapa del proceso y mejorar la comercialización y el almacenamiento. Así mismo, se deben explorar las posibilidades agroindustriales buscando dar localmente el mayor valor agregado posible al producto.

La cercana relación entre los sectores agrícola e industrial, tanto en lo referente a la tecnología de alimentos como a los subsectores industriales que producen insumos para las faenas agrícolas, implica que las decisiones tecnológicas comunes deben beneficiar a ambas actividades. En esta forma, los desarrollos tecnológicos deben apuntar hacia una producción de materias primas de la calidad que requiere la industria y los productores de insumos deben desarrollar la tecnología apropiada a nuestras condiciones de producción.

El tipo de tecnología que corresponde a cada país o a cada región está, en parte, determinado por las condiciones únicas y específicas en lo que hace a la dotación relativa de recursos productivos, a sus condiciones económicas y sociales y al tipo específico de suelo y clima en que se desarrolla la actividad agropecuaria. Por ello, la importación de tecnología de otros países requiere especial cautela para seleccionar la clase de conocimientos generados en el exterior que conviene introducir y adaptar a nuestros procesos de producción.

Una de las principales condiciones para el éxito de la investigación es su continuidad. En este sentido, el horizonte de planeamiento de esta actividad en el campo agrícola debe ser amplio, buscando dar mayor estabilidad a la gran cantidad de proyectos que usualmente superan los cuatro años, factor especialmente válido para el sector forestal.

En cuanto a la transferencia de tecnología, los mecanismos actualmente disponibles en el país han sido diseñados primordialmente para atender a productores empresariales vinculados estrechamente al mercado. Sin embargo, en países como el nuestro existen amplias capas de pequeños productores que enfrentan problemas estructurales y altos riesgos que dificultan la adopción tecnológica. Tales productores proveen buena parte de la oferta alimentaria y de materias primas forestales, razón por la cual es necesario insistir en hacerlos también beneficiarios del cambio tecnológico, desarrollando sistemas de transferencia ajustadas a su racionalidad y a sus medios.

En general, la investigación sin una exitosa transferencia de tecnología carece de sentido práctico y no produce los resultados esperados en términos de incremento de la producción y la productividad. Cuando la adopción es baja, la explicación puede estar en que los incentivos de precios a los productores son inadecuados o los insumos muy costosos. Por esta razón, los esfuerzos realizados para fortalecer la investigación deben acompañarse de medidas que contribuyan a crear un ambiente económico atractivo para las actividades agropecuarias, en particular con respecto a precios y costos de los insumos. Así mismo, los paquetes tecnológicos generados deben consultar la capacidad económica de los potenciales usuarios.

V. MEDIDAS DE POLITICA

A. SISTEMA NACIONAL DE INVESTIGACIONES Y DESARROLLO TECNOLOGICO DEL SECTOR AGRARIO

La adecuada implantación del Plan Nacional de Investigaciones del Sector Agrario requiere la estructuración y puesta en marcha de un modelo institucional que, de una parte, garantice la disponibilidad de fondos y agilidad para desembolsos, y de otra, disponga de un órgano de alto nivel que asesore al Gobierno en lo relacionado con la formulación, orientación y evaluación de las políticas tecnológicas en el sector agropecuario. Conforme a lo anterior, se creará el Sistema Nacional de Investigaciones y Desarrollo Tecnológico, integrado por los siguientes componentes :

- En su estructura operativa, por las entidades públicas directamente responsables de la ejecución de la política tecnológica agraria (ICA e INDERENA) con el apoyo de CONIF, el HIMAT, el Instituto Geográfico Agustín Codazzi, los otros institutos del sector que efectúen investigación, las universidades públicas y privadas, las Secretarías de Agricultura, los centros privados de investigación agropecuaria, los centros internacionales de investigación, y de otros organismos similares que puedan participar en actividades del sistema.

- En su estructura directiva y coordinadora, por el Ministerio de Agricultura, el Departamento Nacional de Planeación y el Consejo Nacional de Investigaciones y Desarrollo Tecnológico del Sector Agrario.

- En su estructura financiera, por los recursos de las entidades del Sistema y por el Fondo Nacional de Investigaciones y Desarrollo Tecnológico del Sector Agrario.

1. Consejo Nacional de Investigaciones y Desarrollo Tecnológico Agrario

Este organismo está llamado a jugar un papel de primordial importancia para orientar las labores del Sistema, a través de su asesoría al Ministerio de Agricultura y el Departamento Nacional de Planeación, en la definición de un esquema de prioridades y la formulación de políticas de investigación y desarrollo tecnológico para el sector agrario en el mediano y largo plazo. Como tal, el Consejo servirá fundamentalmente como un medio de concertación entre las entidades públicas, y entre éstas y las entidades privadas que ejecutan investigación y labores de transferencia de tecnología en el sector. En este sentido, desarrollará una acción orientada a evitar la duplicación y paralelismo de funciones y a clarificar los objetivos de cada entidad involucrada en el Sistema Nacional, organizando y coordinando los esfuerzos del país en materia de investigación científica y tecnológica para el sector agrario.

Para el cumplimiento de estos objetivos, el Consejo operará como un organismo asesor, adscrito al Ministerio de Agricultura, compuesto por representantes del Gobierno, de la comunidad científica y de los gremios, que tendrá, entre sus funciones, la distribución global de los recursos del Fondo Nacional de Investigaciones. Así mismo, el Consejo tendrá una Secretaría Técnica que será desempeñada por COLCIENCIAS, la cual estará encargada de analizar, evaluar y presentar al Consejo los planes y programas que sean sometidos a consideración de este organismo, el cual asignará los recursos del Fondo para los proyectos específicos, sujeto al programa de operaciones que al respecto apruebe el Consejo. Al final de cada ejercicio fiscal, el Consejo presentará al Ministerio de Agricultura, por intermedio de la Secretaría Técnica, un informe de sus actividades.

2. Fondo Nacional de Investigaciones y Desarrollo Tecnológico Agrario

Este Fondo constituirá un mecanismo para el financiamiento de algunas de las actividades investigativas consideradas prioritarias en el Plan Nacional. Su inclusión en el Sistema responde, de una parte, a la insuficiencia de los recursos destinados a la investigación, y de otra parte, a la necesidad de contribuír a mantener un flujo permanente, regular y ágil de recursos que permita la ejecución en forma contínua de los proyectos de investigación prioritarios para el país. Por esta razón, el Fondo debe contar con recursos adicionales a los que actualmente disponen las entidades participantes en el Sistema. En su aspecto operacional, funcionará como una cuenta especial del "Fondo Colombiano de Investigaciones Científicas y Proyectos Especiales Francisco José de Caldas", COLCIENCIAS. En tal caso, los recursos del Fondo de Investigaciones solo podrán destinarse a las actividades que determine el Consejo, y su manejo se orientará mediante un convenio de administración con COLCIENCIAS. Así mismo, a través de este Fondo, las Universidades podrán contar con recursos diferentes a los de su presupuesto para desarrollar proyectos de investigación en el sector agrario.

B. REORDENAMIENTO INSTITUCIONAL

Para posibilitar el funcionamiento del modelo institucional propuesto y el cumplimiento de los objetivos del Plan Nacional de Investigaciones, se buscará un reordenamiento institucional de las entidades encargadas de la investigación, en especial de la estructura técnico-organizativa del ICA y del INDERENA, los principales organismos ejecutores de las políticas de investigación, transferencia de tecnología y educación técnica en el Sector Agrario, con el fin de que asuman el liderazgo que se requiere para estimular el funcionamiento del Sistema y para facilitar la adecuada ejecución del Plan.

C. PARTICIPACION DEL SECTOR PRIVADO

El Consejo establecerá mecanismos que aseguren la participación del sector privado con el propósito de que se canalicen esfuerzos hacia el fomento y desarrollo de productos agropecuarios específicos, en una forma consistente con los requerimientos del sector productivo. Esta participación del sector privado se hará dentro del marco de prioridades definido por el Consejo Nacional de Investigaciones.

El apoyo del sector privado, además de su participación en el Consejo, debe referirse básicamente al aporte de recursos financieros y humanos para fortalecer investigaciones desarrolladas por las entidades oficiales y a convenios entre éstas y el sector privado para adelantar investigaciones específicas.

De otra parte, deben estudiarse con cuidado los proyectos de creación de centros privados de investigación especializados cuando éstos requieran asignaciones de recursos oficiales. Para su consideración, estos proyectos deben demostrar su factibilidad en términos de sus costos y beneficios, en relación con aquellos resultantes de la investigación que se realiza utilizando la capacidad instalada de los centros existentes de investigación.

D. POLITICA DE RECURSOS HUMANOS

El personal técnico-científico para la investigación tiende a constituírse en un recurso escaso debido a la calidad requerida y al tiempo necesario para formar investigadores. De ahí la importancia de definir una clara política de recursos humanos para la investigación. Esta política se refiere básicamente a un plan de capacitación de personal y a un mecanismo para remunerar a los investigadores de una manera competitiva en el mercado laboral.

Los planes de capacitación determinarán la necesidad de profesionales universitarios del país en los diferentes niveles y disciplinas agropecuarias, forestales y pesqueras. Así, las entidades ejecutoras de la política de investigación contarán con programas de capacitación para investigadores que incluyan planes de educación formal y entrenamiento en servicio, lo cual se hará conforme a las políticas y prioridades del Gobierno en materia de investigación.

Así mismo, las unidades administrativas de apoyo a la investigación en las diferentes entidades tendrán mecanismos que permitan mejoras en la remuneración real de los investigadores. A este respecto, se estudiará la posibilidad de que las diferentes entidades tengan un régimen especial en materia de clasificación y salarios, debidamente aprobado por el Servicio Civil. Este tipo de medidas será la única manera, en el largo plazo, de retener investigadores y atraer a estas actividades personal profesional altamente calificado.

La coordinación entre las Universidades y las otras entidades participantes en el sistema permitirá que la preparación de profesionales se desarrolle de acuerdo a las necesidades de investigación del país, haciendo énfasis en la investigación aplicada con preferencia sobre aquella puramente teórica.

E. FINANCIACION

El presupuesto asignado a cada entidad componente del Sistema será la fuente básica para la financiación del Plan y el Fondo Nacional de Investigaciones se constituirá en una fuente complementaria de los recursos de presupuesto para investigación.

Con el objeto de disminuír la inestabilidad de los recursos para investigación se requiere una fuente que los genere en forma permanente y regular y por ello se buscará que el Fondo de Investigaciones se financie con dineros provenientes de los Fondos de Comercialización y Fomento Agropecuario cuyo proyecto de ley cursa en el Congreso. Mientras se define la estructura de éstos, debe estudiarse la posibilidad de contar con recursos del presupuesto nacional, PROEXPO, donaciones y cooperación técnica internacional. Así mismo, el Fondo manejará los ingresos provenientes de los créditos externos actualmente en proceso de contratación por COLCIENCIAS, en la parte pertinente a la investigación agropecuaria, forestal y pesquera.

VI. ESQUEMA INSTITUCIONAL

En primer lugar, siguiendo los criterios establecidos en este documento, el Ministerio de Agricultura, con la colaboración del Departamento Nacional de Planeación y COLCIENCIAS, creará y reglamentará el Consejo y el Fondo Nacional de Investigaciones y Desarrollo Tecnológico Agrario.

En segundo lugar, las principales entidades gubernamentales que sean miembros del Sistema Nacional, y especialmente el ICA, el INDERENA y la Universidad Nacional, tanto como las instituciones privadas que así lo deseen, procederán a elaborar, o continuarán elaborando, sus respectivos planes de investigación 1/. Estos programas serán presentados a consideración del Ministerio de Agricultura y el Departamento Nacional de Planeación quienes se encargarán de estructurar los planes agropecuarios, forestal y pesquero y concertarlos con entidades públicas y privadas, los gremios y representantes de los consumidores. El Consejo constituirá un foro donde se discutan los planes y actuará como organismo asesor del Gobierno. En tercer

1/ El ICA, que ha elaborado su respectivo Plan, debe revisarlo a la luz de los criterios señalados en este documento.

lugar, el Ministerio de Agricultura y el Departamento Nacional de Planeación elaborarán, para consideración del CONPES, una propuesta concreta acerca del mecanismo que permitirá captar recursos adicionales y permanentes para el Fondo. En cuarto lugar, el Ministerio de Agricultura, conjuntamente con las entidades que estime conveniente, conformará un grupo de trabajo para elaborar una propuesta de reestructuración institucional de la función de investigación en el ICA y el INDERENA, la cual será presentada a consideración del CONPES. En quinto lugar, el ICA y el INDERENA elaborarán una propuesta acerca de un régimen especial de clasificación y salarios para los investigadores de dichas entidades, la cual será presentada por el Ministerio de Agricultura al Departamento Administrativo del Servicio Civil para su estudio y aprobación.

PRIMER SEMINARIO SOBRE INVESTIGACION Y DESARROLLO TECNOLOGICO EN EL SECTOR AGROPECUARIO COLOMBIANO

CONCLUSIONES, RECOMENDACIONES Y PLAN DE ACCION

Palmira, Abril 23 de 1982

1. OBJETIVOS Y ORGANIZACION

El propósito central del Seminario fue el de discutir el marco conceptual, las prioridades, los recursos y la financiación de la investigación y el desarrollo tecnológico en Colombia, con el fin de contribuir a la definición de pautas precisas que sirvan para orientar la acción estatal y privada en estos procesos, en consonancia con las necesidades concretas de los agricultores y del desarrollo socio-económico del país.

En ese sentido, el Seminario constituyó un paso significativo dentro del proceso de redefinición y estímulo a las actividades de Ciencia y Tecnología en Colombia, entendidas como un requisito indispensable para el logro de mayores niveles de producción y de bienestar para la población en general. En efecto, durante los últimos años se han tomado medidas y llevado a cabo acciones importantes tales como la inclusión en el Plan Nacional de Integración (PIN) de un Capítulo para el fomento de la Ciencia y la Tecnología, la identificación de los principales limitantes tecnológicos de la producción agropecuaria, la adopción de las Bases para el Plan Nacional de Investigaciones del Sector Agropecuario, Forestal y Pesquero por parte del Consejo Nacional de Política Económica y Social- CONPES, y el gestionamiento ante agencias de crédito externo de considerables recursos financieros para apoyar su ejecución.

Fue deseo de los organizadores del Seminario que las conclusiones y recomendaciones del mismo surgieran de un contexto suficientemente amplio en el cual estuvieran representados tanto los intereses del sector público como del sector privado. Por esta razón además de los especialistas nacionales y extranjeros invitados, participaron representantes de los gremios, asociaciones de productores y dirigentes políticos.

El Seminario fue organizado por el Ministerio de Agricultura, el Departamento Nacional de Planeación, el Fondo Colombiano de Investigaciones Científicas y Proyectos Especiales "Francisco José de Caldas" - COLCIENCIAS y el Instituto Colombiano Agropecuario - ICA. Adicionalmente, el Seminario contó con los auspicios del Fondo Colombiano de Promoción de Exportaciones - PROEXPO, el Fondo Nacional de Proyectos de Desarrollo - FONADE, la Sociedad de Agricultores de Colombia - SAC y el Centro Nacional de Investigaciones de la Caña de Azúcar de Colombia - CENICAÑA.

Participaron también representantes del Banco Mundial, el Centro Internacional de Agricultura Tropical - CIAT, el Centro Internacional de Investigaciones para el Desarrollo - CIID, la FAO, el Instituto Interamericano de Cooperación para la Agricultura - IICA y el Servicio Internacional para la Investigación Agrícola Nacional - ISNAR.

En la sesión de instalación pronunciaron palabras el Doctor John Nickel Director General del CIAT, el Doctor Gustavo Barney Gerente General del ICA, el Doctor Efraím Otero Ruíz Director de COLCIENCIAS y la Doctora Cecilia López de Rodríguez Gerente del FONADE, quien instaló el Seminario en representación del Jefe del Departamento Nacional de Planeación.

El primer día se dedicó a la presentación y discusión del marco conceptual global de la investigación agrícola y el desarrollo tecnológico. Se hicieron exposiciones sobre la innovación inducida como interpretación del cambio tecnológico en el desarrollo; el cambio técnico en el sector agropecuario de América Latina; y las fuentes de financiamiento de la investigación.

El segundo día se concentró en el examen de las organizaciones internacionales para el desarrollo y financiamiento de la investigación agrícola y su relación con los sistemas nacionales; la función y posibilidades del esfuerzo cooperativo e intercambio técnico entre instituciones nacionales de investigación agropecuaria; los elementos requeridos para que la investigación cumpla su objetivo de implantar el desarrollo agropecuario; y la asignación de prioridades a la investigación agropecuaria en Colombia.

El último día se analizó la organización institucional de la investigación agrícola en Colombia y el Plan Nacional de Investigaciones Agropecuarias del ICA; y la función del sector privado en la organización y financiamiento de la investigación agropecuaria en Colombia.

El Seminario concentró su análisis en el sector agropecuario colombiano. Sin embargo, sus organizadores y participantes estuvieron plenamente concientes de la importancia de las investigaciones forestales y pesqueras.

2. ANTECEDENTES Y BASES DE POLITICA

El Gobierno Colombiano, por intermedio del Ministerio de Agricultura, ha venido realizando la investigación agropecuaria. El desenvolvimiento del desarrollo de esta labor se resume a los últimos años.

El Ministerio creó en 1952 la División de Investigaciones Agropecuarias (DIA), responsabilizándola de la investigación de algunos cultivos y especies animales, con el apoyo logístico y económico de la Fundación Rockefeller. Posteriormente, mediante Decreto-Ley, se creó el ICA en 1962 como organismo descentralizado para que se encargara de la generación de tecnología, y también de la educación y extensión agropecuaria. Si bien es cierto, que por ley se creó el Instituto de Investigación, esta actividad no se enmarcó dentro de los programas nacionales de los gobiernos en materia agraria.

En años posteriores a la creación del ICA, los diferentes Gobiernos trabajaron sus políticas agropecuarias, las cuales fueron canalizadas hacia aspectos relacionados con tenencia de la tierra, mejoramiento socio-económico de la población campesina, planes de vivienda, fomento y transferencia tecnológica. Los programas más destacados correspondieron a Plan de Reforma Agraria, las cuatro estrategias, el Plan para cerrar la brecha, en el cual, en su parte de acción rural, se destaca el Programa DRI. Simultáneamente, a partir de 1963, se le adscribieron al ICA nuevas y más funciones tales como supervisión, control, regulación y fomento.

La investigación como herramienta de política agropecuaria se consolida en 1978, año en que el actual Gobierno formuló el Plan de Integración Nacional (PIN). En este Plan, se destaca la investigación como elemento necesario para resolver los problemas del sector agropecuario, el incremento de la producción y la productividad, y si sitúa al ICA como la entidad líder en la programación y ejecución de dicha actividad.

También se señala en el PIN, que para lograr un desarrollo adecuado y armonioso de la investigación, ésta debe estar complentada por acciones de tipo organizacional, financiero y de programación. Consecuentemente, se propone la creación de un Consejo Nacional de Investigaciones y Desarrollo Tecnológico Agrario, de un Fondo Nacional de Investigaciones y de un Plan Nacional de Investigaciones Agropecuarias, Forestales y Pesqueras.

3. MARCO CONCEPTUAL

La experiencia internacional indica que la tecnología se ha convertido en el principal elemento del desarrollo agrario. Este proceso se ha ido haciendo más marcado a medida que el agotamiento de las tierras disponibles para la producción agropecuaria ha traído como consecuencia que el aumento de la productividad por unidad de superficie sea la única alternativa viable.

En los países desarrollados el proceso innovador se ha dado en armonía con la disponibilidad relativa de recursos y ha tendido a posibilitar aumentos en la producción y en la productividad.

En América Latina, y en Colombia en particular la heterogeneidad ecológica y económico-social ha impedido que esta armonía se haya dado de manera general.

El análisis de lo ocurrido muestra de que ha existido cambio técnico, pero que éste se ha dado de manera fragmentaria y en general en forma vinculada a ciertas condiciones de organización social y política económica, particularmente en lo que hace al desarrollo de las condiciones económicas necesarias para asegurar la rentabilidad de las nuevas técnicas.

Esto resalta la importancia de contar con una política tecnológica que permita organizar la demanda de tecnología y articular la oferta a las características y necesidades de ésta.

En toda América Latina y en Colombia se ha hecho un gran esfuezo en el área de generación y transferencia de tecnología a través de acciones de los Institutos Nacionales de Investigación Agropecuaria.

Estas instituciones han sido una pieza fundamental del proceso de modernización y han estado vinculadas directa o indirectamente a la mayoría de las situaciones en donde ha existido cambio tecnológico.

Sin embargo, el propio proceso de cambio técnico experimentado ha ido propiciando a nivel del sector privado un creciente interés por participar en las actividades de investigación y desarrollo tecnológico. Esto junto con la creación de los Centros Internacionales de Investigación Agrícola ha dado lugar a la conformación de un Sistema Nacional de Investigaciones sumamente complejo.

Dentro de este sistema los Institutos Nacionales de Investigación, otrora las únicas fuentes nacionales de oferta de tecnología, comparten responsabilidades con entidades de origen gremial y la empresa privada productora de insumos.

Esta nueva situación crea la necesidad de definir con precisión y claridad las funciones de cada institución y las mejores formas de asegurar para cada una de ellas un nivel de financiamiento adecuado y equitativo.

Adicionalmente crea la necesidad de desarrollar mecanismos institucionales para coordinar los distintos organismos de manera de asegurar todos los niveles de investigación requeridos para el adecuado desarrollo del proceso innovativo.

Por otra parte, la importancia de la tecnología y su estrecha relación con el proceso de desarrollo requiere ser adecuada incersión en los planes de desarrollo económico y con la política global de ciencia y tecnología.

Esta relación entre el proceso tecnológico y los planes de desarrollo puede ser lograda a través de una adecuada definición de prioridades y mecanismos de financiamiento que guíen las actividades de investigación en función de dichas prioridades.

La política tecnológica debe incluir el ordenamiento de prioridades para la investigación y también los instrumentos que permitan desarrollar tanto una estrecha relación entre las instituciones de investigación y los usuarios directos de la tecnología, como la regulación de los componentes tecnológicos provenientes del sector internacional.

4. LA PROBLEMATIGA NACIONAL

El sector agropecuario está pasando por una situación difícil, que se venía fraguando desde finales de la década del 60. Esta situación se manifiesta en la poca competitividad del sector frente al mercado mundial y la importante contribución del crecimiento de los precios de los productos alimenticios al problema inflacionario del país. En buena parte lo anterior se debe a la insuficiencia en la producción de resultados de investigación y paquetes tecnológicos adecuados, debido a los problemas institucionales y financieros del ICA y las demás instituciones que desarrollan actividades de investigación.

Buscando remediar esta situación se han sucedido en los dos últimos años, entre otros, los siguientes hechos :

- Se gestó el Plan Nacional de Investigaciones Agropecuarias del ICA-PLANIA, con el fin de contribuir en forma eficaz a la solución de los problemas agropecuarios del país, recuperando o mejorando la eficiencia del sector.

- El Consejo Nacional de Política Económica y Social adoptó las Bases para el Plan Nacional de Investigaciones del Sector Agropecuario, Forestal y Pesquero en Noviembre de 1981, del cual el PLANIA es uno de sus componentes.

- El Gobierno Nacional convocó una Comisión Sectorial de Concertación para el sector agropecuario, la cual se pronunció específicamente sobre los problemas de investigación y cambio tecnológico del sector.

De manera coherente con lo expresado en los documentos antes indicados, para su ejecución el PLANIA contempla dos instrumentos esenciales :

1.- Definición y aplicación de un Modelo Institucional de investigación y desarrollo tecnológico agropecuario.

2.- Canalización de recursos para investigación según dos componentes :

   2.1. Recursos básicos. Presupuesto asignado a la entidad proveniente de recursos propios, presupuesto nacional y crédito externo.

   2.2. Recursos complementarios, mediante la creación de un Fondo Nacional de Investigaciones y Desarrollo Tecnológico para el Sector Agropecuario, Forestal y Pesquero, cuyas fuentes de recursos serían públicas y privadas.

El modelo institucional estudiado en este Seminario, el cual está contemplado en las Bases para el Plan Nacional de Investigaciones del Sector Agropecuario y que igualmente recomendó la Comisión de Concertación del Sector Agropecuario, parte de la base de separación de las funciones que actualmente cumple el ICA. Las de investigación y transferencia de tecnología a nivel institucional deben ser ejecutadas por un Instituto especializado y las de control, regulación, fiscalización, etc., deben ser ejecutadas por otras agencias del Estado tales como el INCORA.

Recomendaciones Especificas :

- El fortalecimiento efectivo de la capacidad cientifica y tecnológica del sector debe incorporarse dentro de la estrategia de desarrollo que adopte el próximo gobierno.

- El próximo gobierno debe ser consciente de que no habrá desarrollo cientifico y tecnológico sino se canalizan recursos en forma suficiente y estable para financiar dichas actividades.

Por consiguiente, es necesario continuar la tarea de buscar y concretar nuevas fuentes de recursos. El futuro gobierno debe reconocer que una fuente muy importante de financiamiento seguirá siendo el Presupuesto Nacional. Además el Gobierno debe comprender la necesidad de ser garante de créditos para investigación y asumir el compromiso de tramitar ante el Congreso Nacional la adopción de los decretos y leyes que garanticen la captación de recursos financieros permanentes para garantizar la estabilidad y continuidad de los procesos de investigación agropecuaria, forestal y pesquera.

El sector privado a través de sus diferentes agremiaciones y organizaciones debe comprometerse a participar en la financiación y orientación de la investigación.

Vital importancia reviste para el país el establecimiento y ejecución de una política tecnológica clara y con objetivos definidos para el sector forestal. Por sus características y problemáticas especiales deberá ser establecida en el tiempo y basada en investigación sistemática que produzca las herramientas indispensables para el logro del manejo racional de los bosques naturales y su aprovechamiento eficiente a fin de encontrar soluciones a la desmesurada devastación de nuestro recurso natural renovable más importante.

Asimismo, es necesario dar respuesta tecnológica al sub-sector reforestación en los campos de manejo silvicultural, utilización de la madera y mercadeo racional de la misma.

Por otra parte, se reconoce la importancia de los recursos pesqueros los cuales requieren planes deinvestigación científica y tecnológica para su real incorporación a la economía nacional.

5. PLAN DE ACCION

A la luz del documento, adoptado por el Consejo Nacional de Política Económica y Social, denominado "Bases para el Plan Nacional de Investigaciones del Sector Agropecuario, Forestal y Pesquero", el ICA debe proceder a revisar su Plan de Investigaciónes. Esta revisión debería hacerse a la mayor brevedad a efectos de iniciar su ejecución en el menor tiempo posible.

Dado que uno de los mecanismos para el desarrollo del sector agropecuario aprobado por el CONPES, ha sido la necesidad de constituir un Consejo Nacional de Investigaciones y Desarrollo Tecnológico Agrario y el Fondo Nacional de Investigaciones, se recomienda con carácter urgente la creación del Consejo puesto que el papel principal del mismo corresponde a la definición de un esquema de prioridades para el sector agropecuario en el mediano y largo plazo y la orientación de las actividades del Fondo.

Para poner en práctica esta recomendación se requiere la conformación de un grupo de trabajo constituído por representantes del Ministerio de Agricultura, el Instituto Colombiano Agropecuario, COLCIENCIAS, INDERENA, CONIF y la Sociedad de Agricultores de Colombia, para elaborar el respectivo proyecto de decreto, el cual deberá ser presentado al Señor Ministro en un término no mayor de 60 días.

Con base en las recomendaciones y sugerencias presentadas en este Seminario, el Ministerio de Agricultura deberá conformar un grupo de trabajo para elaborar la propuesta definitiva de reestructuración institucional del ICA la cual será presentada a consideración del CONPES.

Con el propósito de promover una mayor participación de las instituciones universitarias en las actividades de investigación del sector agropecuario, se creará un grupo de trabajo conformado por representantes del ICA, ICFES y COLCIENCIAS, Este grupo tendrá como función principal la de servir como mecanismo de coordinación de los programas y proyectos de investigación que se lleven a cabo en las universidades.

En un término no superior a dos años COLCIENCIAS convocará a su Segundo Seminario sobre Investigación y Desarrollo en el Sector Agropecuario. El objetivo de éste será el de evaluar el cumplimiento del programa de acción propuesto. Igualmente dar continuidad al proceso de discusión y consulta iniciado en este Seminario.