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FARMING SYSTEMS FOR THE SAN JULIAN COLONIZATION AREA

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I. OVERVIEW

A. Background

1. Bolivia's population of slightly over five million is heavily concentrated on the Altiplano and high mountain valleys and slopes. About sixty percent of the population is rural with over ninety percent of these being classified as small farmers eking out on existence through the production of potatoes, barley, wheat and vegetables, largely on marginal lands.

2. One of the principal strategies of Bolivian domestic policy in recent years has been the settlement and development of the Orient. As a means of achieving integration of this area the Government of Bolivia (GOB) began to construct roads from the main highland centers of Cochabamba and La Paz into the Lowlands. As one means of helping to solve the problem of increasing national food shortages and overpopulation in the highlands the GOB began to promote the colonization and agrarian development of the Orient by further extending and improving access roads, constructing processing plants for agricultural products, developing agricultural experiment stations and implementing colonization projects. As a result of these efforts over 50,000 families have moved eastward to new farm lands, while large numbers have migrated eastward as farm laborers or workers in related agro-industry.

3. Much of the internal migration, part of the directed resettlement and all of the immigrant colonization in Bolivia since 1954, has taken place around Santa Cruz. This migration largely reflects the greater potential for agriculture in this area in comparison to the Alto Beni and the Chapare.

B. Soils and Climate

4. The best agricultural lands in Bolivia are in Santa Cruz Department, and some of the best land in Santa Cruz is in the San Julian project area. About one-third of the project area has been soil-mapped at the scale 1:40,000, by GOB soils agronomists under the guidance of T.T. Cochrane of The British Tropical Agricultural Mission. By extrapolating the map to include the entire project area it has been estimated that over half of the area is Class I and Class II land with another 15% being Class III - all suitable for continuous cropping.[1/] The remaining one-fourth of the land is generally poorly drained and would require the installation of drainage systems to have continuous cropping. In practice these areas are being excluded from settlement nucleos. The soils are generally alluvial, ranging from sandy loams to silty loams to clay loams. They are well-suited to crops now grown in the area and should perform well with a wide range of new crops and varieties that might be introduced.

1/ T.T. Cochrane, of the British Technical Mission, made his tentative classification of the soils in the Santa Cruz region in terms of: "Soil, Suites," Definitions proposed for FAO "Soil Map of South America, and the US Comprehensive 'assification." The classifications were very tentative.

5. Based on sketchy precipitation and temperature data, annual rainfall in the drier, southeastern portion appears to be 850 to 900 mm, and the northeastern sections reach 1100 to 1500 mm. Although some rainfall is registered for almost every month of the year, heavier concentrations are from September to February (Summer). Although rainfall patterns vary considerably from year to year, it may be useful to note the 1978-1979 data taken at the project center of Los Cafés, in the drier portion of the project area.

mm

1978		1979	
June	232.2	January	167.8
July	6.8	February	121.3
August	37.0	March	59.5
September	46.4	April	90.9
October	131.5	May	41.4
November	174.0	Total	1,265.0
December	156.1		

6. Annual temperature vary from 25.4°C in summer to 18.8°C in the winter months. The range of temperature allows for the production of an extremely wide range of annual crops. While the area is usually frost-free, an occasional frost increases the risk factor for

pure tropical crops such as African oil palm and cacao south of nucleo 38.

7. Winter winds are quite strong; however, their impact in the project area is greatly diminished by the green belts around the nucleos and should be further combatted by farm windbreaks proposed in the farming systems plan.

II. AGRICULTURAL PRODUCTION BASE AND STRATEGY

A. Current Situation

1. Strategies

1. Settlers in the San Julian project area are benefiting from lessons learned the hard way by the GOB in former colonization projects. The fact that recent project evaluations conclude that the project is now ready for the consolidation phase,[1/] indicates rapid progress under the semi-directed nucleo development pattern. An orientation program, which is quite intensive during the first four months of settlement, has evolved into a key element in helping assure

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1/ Evaluation of Chane-Piraí and San Julian Colonization projects by Michael Nelson, November, 1978.
San Julian Evaluation by The Rural and Administrative Development Office of the Development Support Bureau, April, 1979.

the success of new colono groups. The program can be further strengthened agronomically and developed into the principal tool for training and guiding the colonos through the consolidation phase, establishing them as fully integrated members of the rural economy.

2. By the allocation of fifty hectares of prime agricultural land to each family, the GOB is wisely avoiding an early repetition of the minifundio problems of the Altiplano. This land base is adequate to permit the emergence, over time, of large numbers of middle-class farmers active in the country's internal market economy and producing increasing quantities of export commodities.

3. The nuclear development pattern, which settles 40 families around a village center with landholdings extending outward as the spokes of a wheel, has several advantages over lenial or block systems, the most important being the close proximity of the people for social interchanges, technical guidance inputs, common marketing arrangements, health services, potable water and education of adults as well as children.

2. Farming System

4. Colonists in the San Julian project area are practicing the traditional, slash-and-burn farming system. It consists of the complete destruction of all timber and brush by clear-cutting an area

and burning all residue except for a few high valued species that may be or have been pirated by "tronqueros." After burning the cut-over areas the land is cultivated for up to three years before letting it grow back into brush cover. The principal reason for not cultivating the land for a longer period is the difficulty of controlling the rapid intrusion of weeds and grasses with the primitive tools they have. Utilizing this traditional system, new colonists cultivate an average of about one hectare in rice, corn, some fruit trees and vegetables the first year. The second year they clear an additional hectare and follow about the same cropping pattern. Thereafterward, with family labor they are able to cultivate an average of three hectares in the summer and one hectare in the winter. In order to cultivate more than this amount the colono must hire labor for the majority of operations, including land clearing, weeding and harvesting.

5. This traditional system practiced by thousands of colonists is rapidly depleting the forest, which is one of Bolivia's most valuable natural resources. The system is counterproductive for the colono. At any given time he will have only three to four hectares under cultivation. This severly limits his income, which limits his ability to invest in improving the system. His investment in land clearing is only about 20% effective, in that he is using excellent

quality land only three years out of fifteen. There is a further danger that the farmer will cut through all of his virgin timber and then abandon his holding completely.

6. Maize and rice are the main cash crops. Seed of improved varieties are available and production per hectare is good for a slash-and-burn system. Fruit trees and vegetable planting material are given to the colonos during orientation. By the end of the first year the new farmer has entered into the cash economy with his rice and maize. He is producing the bulk of his own food supply from such crops as vegetables, cowpeas (Vigna unguiculata), bananas and yuca (casava, manioc) traditional varieties are generally used. New germ plasm and additional species are urgently needed.

B. Consolidation Strategy

1. Individual initiative, minimal services

7. The GOB is following an strategy of low-cost per family settled with high dependence upon individual initiative and active private sector participation. This strategy seems entirely appropriate for the San Julian project. The proposed bridge over the Rio Grande is vital to the success of the project.

2. Reorientation

8. From observations made on the existing farms it is obvious that there has been a direct transfer of antiquated, highland technology to the lowlands as well as the adoption of some traditional lowland practices. During orientation and for an extended period thereafterward, the colonos are highly receptive to adopting new technologies and new methodologies. If this opportunity is lost the GOB will simply contribute to the destruction of its valuable natural resources in the lowlands by people who will remain poor with their traditional, technologies.

3. Permanent agriculture

9. The pace of slash-and-burn can be slowed down considerably by the immediate introduction of systems designed to permit permanent cropping with hand labor and traditional tools. Such systems would be designed to greatly reduce weed intrusion. They are proving to be highly effective in many areas of the world having similar agronomic conditions to the project area. Multiple cropping and continuous cropping throughout the year keeps the ground shaded, thus reduces weed growth and increases overall production per unit area.

4. Integration of crop and livestock production

10. Use of the above systems indicates the desireability of closely integrating livestock production with crop production. Surplus production, crop residue and production that does not meet market standards, as well as legume forage used in crop rotations can all be marketed successfully through swine, dairy or beef production.

5. Credit

11. Use of credit for farmers in the project area should be given only to those farmers practicing one of the above systems of weed control or preferably a combination of these systems.

6. Forest exploitation to capitalize colono farms

12. There seems to be an opportunity for the GOB to develop forestry exploitation strategies that could materially lower the cost of colonization as well as help capitalize the colonos.

7. Diversification of farm enterprises

13. A diversity of enterprises at the farm level should be encouraged. The farmer will benefit from spreading his risk. Bolivia's fragile market structure will also benefit by not having an

over-production of chronically surplus commodities. Animal traction or mechanical traction for weed control is difficult to practice before the stumps have been removed from the area.

8. Involvement of the private sector

14. The consolidation strategy should encourage full-scale private sector involvement in the development process. Integration of agro-industries with the production of raw materials should be promoted. For example, a processor of tomatoes should make contracts directly with farmers, provide technical assistance and receive the product at a pre-agreed price from a "centro de acopio" located at the nuclear level.

15. Chemical weed control utilizing a knapsack sprayer with a shield attached to the sprayer nozzle can be effective for pre-emergence weed control. CIAT weed control specialists, well qualified to give detailed recommendations and instructions, should be made. available to the project.

16. Minimum tillage or no-tillage farming techniques favor weed control as well as provide other benefits, including moisture conservation and the avoidance of root damage in mechanical weed control. In several parts of the world maize and beans produced by no-tillage methods, out-yield maize and bean crops produced under conventional tillage.

III. BASIC FARM ENTERPRISES

1. Many of the crops discussed in this section are well-known and well-adapted in the project area. Other crops discussed are highly successful in similar geographic regions and have a high potential for the area.

A. Maize

1. Importance

2. It is anticipated that for several years maize will continue to be the most important cash crop in the San Julian area. Market outlook is good in the long run, although continued wide price fluctuations are likely in the short run.

3. The production of maize in Santa Cruz is a small farmer enterprise. The Development Corporation estimates that 80% of the maize is produced by manual labor with an average production of 1,754 kg/ha. Wing's "Datos de Investigación" for San Julian showed an average maize production of 2,012 kg per hectare. This reflects the advantage of better soils in the project area utilizing traditional methods. This production is entirely too low, however, and could be greatly improved by adapting relatively inexpensive technology.

2. Technology

4. The Centro de Investigación Agrícola Tropical (CIAT) has developed recommended cultural practices and prolific varieties adapted to the project area. These varieties are:

Variety	Color	Prod. in kg/ha.*
Tuxpiño/p/g	White	6,152
Sinthetic (q) 10 lines	Yellos	6,132
La Posta	White	5,692
Cuban Yellow	Yellow	5,200

* Comparative yield trials at Saavedra and El Vallecito

3. Problem of weed control

5. Failure to control weed growth can reduce production by more than one-half. Weed control can be accomplished with chemicals or mechanically by hand. The latter method requires more labor and causes root damage, thus lowering yield and profit. Pre-emergent weed control is usually most effective; however post-emergent chemical treatment gives satisfactory results. (Ultra low-volume, directed herbicides are used in post-emergent treatment successfully in an AID project implemented by Experience, Incorporated in Tanzania.

The system, manufactured by Ciba Geigi, is powered by two, D-type flashlight batteries.) CIAT agronomists have developed modern appropriate procedures for chemical weed control. No-till techniques and multiple cropping are also effective weed control measures.

4. Post-harvest crop protection

6. A survey of the project area indicates that post-harvest losses in the San Julian area from rats, rotting, mold and insects is running from 15 to 25 percent. In order to reduce these losses it is considered advisable to make credit available to individual farmers for the construction of drying patios and a rat-proof grain storage barns. This storage facility would also enable the farmers to hold their grain for a reasonable period after harvest, thus avoiding the annual harvest season slump.

B. Rice

1. Farming system

Most of the rice in Santa Cruz is now produced by colonos using traditional technology. Rice is the second most important crop in the San Julian project area with an average paddy yield of 1,417 kg/ha., while the average for the Department is 1,700 kg/ha. This difference probably reflects heavier plantings in the lower rainfall

zone of the project as well as low-yielding varieties, low-seeding rates and poor technology in the higher rainfall zone. All plantings in the area are upland rice which normally yields considerably less per unit area than paddy rice.

2. New technology

8. CIAT recommends the following varieties:

Variety	Days to Maturity	Demonstration Plot Yields Kg/ha 1/
Bluebonnet sel	140	11,110
Cica-6	130	8,080
Bluebelle	95	9,810

9. It is clear that extension agents working directly with colonos with technical backstopping from CIAT rice technicians can make rice a much more productive crop in the area. Improved technology should include the use of better varieties, weed control, insect and disease control, improved harvesting methods, better drying methods and adequate, well ventilated storage.

1/ It is not clear whether this is for one a two crops per year.

3. Labor constraints

10. Colonos in San Julian are under a severe labor constraint that limits their capacity to farming not more than three or possibly four hectares per year. Rice growing under traditional technology appears to demand an excessive number of person-days of labor for harvesting and threshing. Estimates are that 20 person-days are required for harvesting by taking just the grain spikes from the plant. Six additional days are said to be required for hand threshing. As the yield per hectare increases the person-days required for harvesting and threshing may well exceed forty. Farmers should be taught to cut and handle the rice plants and place them in shocks for drying. This may be done with sythe or machette. Credit should be made available for stationary threshers to do custom threshing. Simple, foot-powered threshers have been devised and could be effective if properly demonstrated in San Julian. Hand-threshing on a simple, pole-constructed table is also effective. Since rice is usually harvested with a moisture content of from 18 to 24 percent, it must be further dried before storage. The availability of credit to construct drying patios and grain storage barns at the farm level will greatly reduce post harvest losses.

C. Beans and Other Edible Legumes

1. Demand

11. Beans are becoming an important source of protein in the diet of the San Julian colonos despite the fact that they consumed a minimal quantity before migrating to the Lowlands. It was noted that both beans and cowpeas are readily accepted in the daily diets. Large numbers of migrant workers as well as the urban centers in the Lowlands represent a growing market for beans. Black beans have a considerable potential as an export commodity, although red beans may also be exported in perhaps lesser volumes. With Ethiopia's recent departure from the export market, navy beans are in world short supply and are likely to be for many years. Beans are especially attractive crops for San Julian, due to high-unit value, thus reducing transportation as a percentage of production cost.

D. Root and Fiber Crops

12. Soils and climatic factors in the project area favor the production of a wide range of fibers and root crops. Production from these crops can be consumed directly by the colonist, sold in national markets or marketed through the production of livestock. Yuca, malanga, yautia, and sweet potatoes are proven feeds for swine and can be harvested by pigs by utilizing a simple, movable, battery-powered

electric fence. These crops, chopped, make good supplementary feed for dairy animals.

1. Yuca

13. A basic element in the diets of the lowland population is Yuca. The Department of Santa Cruz produces more than half of the over 290,000 ton national, annual production. Local varieties are utilized in the project area and are yielding marketable quality yuca. Both quality and quantity of production could be improved by introducing the latest released varieties from CIAT, the international research center located in Colombia. Yuca production can be industrialized to make starch for domestic consumption or export.

14. Yuca is also the basic ingredient for producing the widely used tapioca pudding. Since the market shelf life of yuca is quite short, 10 days to two weeks, colonos should be prepared to hog-off production that cannot readily be absorbed into the fresh market or industrialized.

2. Potatoes

15. Potatoes are second only to maize in area planted in Bolivia but occupy first place in tonnage, averaging over 750,000 tons per year for the past several years. Potatoes yield well in the

project area on lands having residual moisture or in higher rainfall areas during the winter months. When there is a shortfall in production in Cochabamba or La Paz, the principal production areas for the country, there could be an excellent opportunity for the colonos to quickly plant a large winter crop in order to take advantage of higher prices. A "catch crop" planting of potatoes in time of shortage could also reduce the necessity of importation.

3. Sweet potatoes

16. Almost every farm in San Julian has sweet potatoes growing as a subsistence food crop. Vine growth is vigorous, thus providing an excellent ground cover for weed control. The varieties noted were inferior to commercial varieties grown in other countries. Cultural practices are poor. Improved varieties should be introduced, observed at the agricultural center and worked into the local farming systems. Instructions in cultural practice plus planting material could be made available to colonos.

17. The sweet potato has a much longer shelf life than yuca. With improved varietis, market demand for sweet potatoes should increase steadily. Any surplus production can be utilized for hogging-off or as chopped feed supplement for dairy cattle. The vines make highly palatable, nutritious forage.

E. Fruit and Vegetables

1. Adaptability

18. The considerable temperature range from winter to summer in the project area permits the production of almost all of the different fruits and vegetables, notably excepting fruits requiring an annual, dormant chill period (pome and stone fruits). Vegetable seed and some fruit trees have been given to arriving colonos during the orientation period. The settlers have taken full advantage of this planting material, quickly establishing self-sufficiency in home food production. There is ample evidence that many families are already marketing the surplus production in Montero and Santa Cruz. Items marketed include tomatoes, sweet and hot peppers, plantain, melons, beans, sweet corn, sweet potatoes and yuca. The settlers have brought in seed and plants from a wide range of sources. They have not, however, been able to secure, for the most part, improved varieties. The agricultural center at the project level should play an active role in introducing, testing, multiplying and making available to farmers improved varieties of seed and plant material. Improved germ plasm can be made available to new colonists during orientation. Commercial nurseries and seed farms should be encouraged to develope and provide continuing and expanding sources.

2. Marketing

19. Marketing fresh fruits and vegetables is difficult, requiring a high degree technical capability. The problem in San Julian is compounded by the lack of a bridge over the Rio Grande. Marketing losses in Bolivia are extremely high. For a large number of fruits and vegetables new varieties have been developed which have more uniformity, higher production potential and are more resistant to marketing damage.

3. Strategy

20. Consolidation strategy for the San Julian project area calls for a wide diversity of crops in order that the colonists may better cope with Bolivia's fragile market structure. Where domestic or export market potential exists settlers would be encouraged to stress the production of permanent tree crops. It is recommended that initially the agricultural center, backstopped by CIAT's experiment station, collect the best germ plasm available worldwide. Species to be collected and multiplied should include avocado, coconut, achiote, lime, grapefruit, papaya, mango, orange and other citrus. Attention should be given to varieties within species that would give the widest possible spread in the harvest season. The first thrust

in distribution would be to make available to colonos a range of species and varieties that would assure a nutritious subsistence food supply throughout most of the year. With the foundation germ plasm in place, commercial expansion of species having good market demand would be pursued.

4. Bananas and Plantain

21. The area devoted to the production of bananas and plantain in Bolivia increased from 16,600 hectares in 1972 to 22,700 hectares in 1977. The annual production of over 370,000 tons of these fruits is ample evidence of their importance in the Bolivian diet. A wide range of varieties was noted in the markets of La Paz, Cochabamba and Santa Cruz. Many of these varieties are of poor quality, have limited shelf life and low production per unit area. Mos of the colonists in the project area already have these inferior varieties. Bananas and plantains could become an important commercial crop with the aid of introducing and multiplying superior varieties in the project area and teaching improved cultural practices. Better varieties grown with sound technology would compete favorably in the domestic market.

5. Citrus

22. Soil and climatic conditions in San Julian area are ideal for citrus production. If the area is going to be competitive in the domestic markets, however, it will have to be on the basis of producing quality fruit from improved varieties. Off-season varieties will help reduce competition from other producing areas. Some varieties of improved species are already available at Saavedra and the university experimental farm. Additional clones should be brought in, and permanent budwood gardens should be established. Multiplication can best be done at the project agricultural center. Plastic bags should be used to grow the plants in order to reduce losses when transferred to the farmers.

6. Asparagus

23. Green asparagus would likely be adapted to the project area as a winter crop. There is a growing shortage of whole green asparagus in the U.S. market, with shifting farm labor to industrial and service jobs. We have a client who is searching for a source of at least 2000 tons of canned, whole green asparagus. There is a canning plant at Montero which is not operating due to the lack of marketable supplies. Our client would impose strict quality standards. The success of the enterprise would depend, first on a bridge over the Rio Grande, then on close linkages between the client, the local packer and the farmer.

7. Chilies

24. Pepper (Capsicum) appears to be well adopted to the project area. There is a rapidly increasing supply-demand gap for hot chilies (Capsicum frutescens). There is a rapidly growing market for Mexican and South Asian food (highly seasoned with chilies) in the United States. At the same time there is a decline in world supply due to the shifting of farm workers from Louisiana and Mexico to industrial environments and due to deteriorating grade quality of India's export offerings. We have a client who is searching for a new source of 20,000 tons of dried chilies per year and would provide the seed for its production. Hypothetically this could be an ideal cash crop for the San Julian area. It has a high unit value, thus making the cost of transportation feasible, and it can be sun-dried.

F. Industrial Crops

25. The San Julian project area is richly endowed with productive capacity for a wide range of industrial crops that will most likely continue to enjoy sustained world market demand. By having access to efficient, adapted germ plasm, the colonists would be in position to take advantage of market opportunities as their farming skills and financial resources permit.

1. Oil crops

26. Peanuts, soybeans, cotton and sesame are well adapted to the soil and climate of the project area. Market outlet for these products is highly favorable due to the demand from oil extraction plants located in Santa Cruz, Cochabamba, Chuquisaca and Tarija. All of these plants have unutilized capacity, and the GOB policy is to become self-sufficient in vegetable oils. The project management needs to encourage the oil extraction plants to integrate their industry in order to improve the operating efficiency of the oil processing plants. The colonists would profit from marketing contracts and from technical guidance from oil company agronomists who could be included in an integrated package.

2. Peanuts

27. Peanuts should become an important crop in the area. They can be interplanted with maize and help keep weeds under control. Production labor is not excessive; more labor is required for the harvesting operations, however, the price outlook over the medium to long term is good.

3. Soybeans

28. Soybeans grow well in the area and the area production can be increased by providing the services of stationary threshers in the nucleos. The beans should be cut and shocked for further drying before they are threshed, either by hand or machine.

29. Although grown primarily as a fiber crop cotton is also an important oil crop. Approximately 15 percent of the total product is a high-grade, edible oil.

4. Sesame

30. Sesame could become an important a source of vegetable oil, or for use in the export or domestic confectionary industry. It could be an important crop in the project area when used as the last crop in an annual multiple cropping cycle. Sesame is quite drought-resistant and will keep the ground covered well into the dry season r thus helping reduce weed growth. The expected yield would be about 800 kg per hectare.

5. Fiber crops

31. a. General possibilities.- Fiber crops are a diverse group of plants, all of which contain or produce fibers of sufficient length, strength, and durability to be utilized in the manufacture of cloth, bagging, cordage and numerous other articles. Cotton is the most important fiber crop in the world. Other important fiber crops that can be produced in San Julian include kenaf, ramie, sisal and abaca or hemp. The price of petroleum in the world market has raised the cost of producing synthetic fiber to the point that production of natural fibers now offer renewed opportunities as cash crops.

32. Sisal is grown in Bolivia to a limited extent. It could become economically important in the lower rainfall portions of the project area.

33. Ramie could become an important crop in the higher rainfall areas. The fiber is used to make fish nets, "grass linen" shirts, table cloths, etc. It also makes excellent, thick-piled rugs. This plant may offer an opportunity for Altiplano women to continue their tradition in handicrafts.

The leaves of the ramie plant are over 20 percent protein and make an excellent green-chop feed for swine. Kenaf and abaca would do well in the higher rainfall areas. These plant fibers are used principally for bagging and cordage.

34. Borrow pits left by the roadside in the project area could be utilized in the retting process for the above-mentioned fiber crops.

35. Serious consideration for more than token production of these crops would be contingent upon the initiation of an integrated agro-industry whereby the mill would provide technical guidance and agree to purchase the production at a pre-agreed upon price.

36. b. Cotton. Cotton production has declined steadily over the past several years from 68,000 hectares in 1973 to 34,000 hectares in 1979. The Cotton Producers Association forecasts that only 25,000 to 27,000 hectares will be planted for the 1980 crop. The decline is likely due to decreasing effectiveness of chemical insecticides and the failure of the farmer to employ integrated pest management programs. The GOB is concerned that the area planted by large scale producers will continue to decline as soybean production continues to increase. Efforts are therefore being made to include small farmers in cotton production. CIAT, with technical assistance from the British Overseas Development Mission, initiated production trials in San Julian in 1979. The tests were reported to be encouraging, and more extensive

trials are to be made in the 1980 crop season. In other parts of the world small farmer cotton production has been successful under close technical supervision. Technical guidance in pest management is absolutely essential. It can be provided either by the cotton industry or by government. If cotton does become an important crop in San Julian one can expect an increase in the pace of mechanized land clearing with the subsequent increased use of mechanized farm power.

37. c. Sugar cane.- Bolivia produces approximately 255,000 tons of raw sugar and exports 78,000 tons, most of which is produced in SAnta Cruz Department.

Sugar cane is a highly efficient energy storing crop which is easy to grow. The plants cover the ground at an early stage of development thus greatly reducing weed growth.

38. San Julian soils appear to be well-suited to sugar cane production when the market situation so favors it.

39. d. Coconuts.- The planting of coconut palm has been neglected in Bolivia. This may be due to an erroneous belief that the plant is only adapted to coastal areas. Coconuts thrive at elevations up to 300 meters and at 26 degrees of latitudes, and with up to approximately 1500 mm of annual rainfall, or in drier areas with

a relatively high water tables. FAO estimated gross returns per hectare of coconuts, to be $418 for 1970 and $605 for 1990 in constant dollars. The current asking price for a small coconut in La Paz is $0.60. It has been estimated that over 400 million persons in tropical regions use coconut oil as their principal source of cooking fats. Copra with fat removed contains 18.2 percent digestable protein when fed to animals. By the sixth year the settler is ready to begin marketing a semi-perishable product, either as copra or as dried nuts. Coconuts can be interplanted in a multiple cropping system for the first three years. By the fourth year a family can begin harvesting coconuts for domestic consumption.

41. e. African oil palm. One of the best of all oil producing plants, the African oil palm, may be well adapted to the higher rainfall areas in the north of the project area. Initial test plantings should be made by providing three or four plants to each farmer as part of his orientation package beginning at about nucleo 38. These few palms, if adapted to the area, will provide all the family's vegetable oil requirements. The fruit is smashed in a pilon (the same as used for hulling rice) and placed in a pot of water for boil-

ing. The oil will separate from the fiberous mass and rise to the top of the water. It is then skimmed off as redish colored oil that is excellent in all types of household cooking.

42. Hybrid oil palm varieties have a production potential of up to four tons of oil per hectare per year. If the dooryard plantings outlined above prove successful commercial plantings may then be made through cooperatives. In order to justify on extraction plant, at least 100 hectares of palms is required. The more efficient plants require 2,000 hectares of palms.

43. f. Cacao.- Current world prices are very high, and predictions by FAO indicate that world supply will be somewhat short of world demand over the medium term. They further predict that prices probably will never again fall so low that the crop will be unprofitable for the producer. Cacao plantings should be made on a trial basis from Nucleo 38 northward. These trials can be placed in reduced shade from the large, high quality forest trees. If proven adaptable, cacao can be a highly important cash crop for the northern part of the project area.

G. Forestry

44. A conservative estimate of timber reserves on the parcels indicates a valuable resource that could appreciably help the colono capitalize his new farming operation. With the access road available, it is estimated that the colono could receive from the tronquero $25 per thousand board ft. Estimates of standing timber per hectare range from 25,000 in the dry and palm areas to 50,000 board feet in the higher rainfall area. This amounts to $600 to $1,200 per hectare. The total value of timber per 50 hectare farm ranges from $18,750 to $30,000. The major portion of this resource, is being slashed and burned with little or no rational harvesting taking place. It seems logical to conclude that through prudent management of these timber resources the GOB could finance its entire colonization program.

45. There appears to be considerable confusion in the project area concerning the ownership and rights to harvest timber growing on the colonos' allotted parcels and the green belt separating the nucleo. It is said that timber concessions covered all of the San Julian project area prior to project initiation. Were these concessions revoked? Do the colonists and NADEPAs have the right of harvest if they pay the forestry tax? These questions remain unanswered at the project site.

46. It is recommended that the GOB carefully reassess its policies for forest exploitation with special attention given to the project area to, 1) a review of existing timber harvesting concessions, 2) the revocation of concessions where feasible, 3) allocation of forest resources to the colony with resources on individual plots going to the colono and resources of the green belts going to the NADEPAs to support public works, and 4) technical assistance in forest management to colonists and NADEPAs.

H. Livestock

47. In many Bolivian colonization areas there has been a definate pattern of slash-and-burn agriculture which produces two or three crops before grass and weed infestation rule out further cropping under traditional methods, followed by abandonment of the land to extensive cattle production. This system may have its merits in marginal land areas. However, in areas where the land is in Soil Classes I, II or III, suitable for continuous cropping, it is in the national interest to strongly discourage extensive livestock production. Bolivia has vast land areas that are extremely well adapted to extensive livestock production but the areas of lands suitable for continuous cropping are much more limited. Prime crop

lands devoted to intensive,mixed,animal and crop production tend to give the highest returns per unit area to both the farmer and the country. Since the San Julian project soils are of excellent quality, suitable for continuous cropping, this project for the consolidation phase of development is based upon integrated crop and livestock production.

48. Multiple cropping and minimum tillage systems discussed in Chapter II will leave large quantities of crop residue or produce that is below market grade that can be converted into a saleable product through animals.

49. The crop model we propose calls for enterplanting maize with kudzu, centocema, lab lab or other palatable, viney legumes (See Chapter IV System Five for a more detailed discussion). Since the legume will be left on the land for at least two years during the rotation there should always be plenty of quality legume pasture for livestock.

1. Cattle

50. The integration of cattle into the colonos' diversified farm plan is purposely paced over a long time span. The plan has been

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well as the skills and preferences of individual farmers. It is likely that the cash crops presently grown will account for the majority of farm income over the next several years while new plant material is being tested and multiplied and while farmers are learning to handle broader crop mixes and develop market outlets for them.

3. There is substantial agreement among agronomists that the major reason for abandoning land in San Julian area after two or three crops is the rapid invasion of weeds and grasses, and not so much due to depletion of soil fertility. The farming models given below incorporate cultural practices that, if followed, will greatly reduce weed competition, thus, permiting continuous cropping. Essential guidelines to these cultural practices include: 1) intercropping and multiple cropping to keep the ground shaded as much of the time as possible, 2) increasing plant densities, 3) use of minimum tillage or no-tillage techniques, and 4) ridging of poorly drained soils. The ridges can be a meter apart and built up with a hoe in the absence of animal power. They should be servicable for several years with only slight rebuilding under multiple cropping or no-tillage systems.

4. The area of land under cultivation by a farmer is the product of the time since his arrival in the colony (a short time up to six years) and the amount of labor directed toward land clearing. Since there is such a wide range of cultivated land per farmer, crop rotations are discussed on the basis of systems per hectare per year. Thus, farm plans as well as costs and returns may be computed from the one hectare models.

A. System I: Maize/Beans: Hand Labor

5. Land is prepared by slash-and-burn or by throughly re-clearing land that has been previously cropped. Ridges, approximately one meter apart, 25 cm high at the center and 30-40 cm wide at the base are made with hoe or shovel. Maize is planted at 25 cm intervals in the center of the ridge and thinned to one plant per hill. This gives a plant population of 40,000 per hectare, which under favorable rainfall conditions will rapidly shade the ground, thus depressing weed population and weed growth. Weeds that appear must be eliminated before they are over four cm high. This may be done by a light-weight weeding hoe or by directed herbicides.

6. When the maize is flowering beans or cowpeas are planted on the ridge between the stalks of maize. The bean population will

also be 40,000 hills per hectare. Continue weed elimination as required, using a weedking hoe only.

7. After harvesting, crop residue is chopped up with a machette and left as a mulch on the land. Maize may be planted the next year, or another annual rotation series may be started, leading off with rice.

B. System II: Rice/Maize Soybeans: Hand Labor

8. The land is prepared by slash-and-burn or by thoroughly reclearing bush land. Ridges are not required, although previously ridged land may be used. Plant rice in rows approximately 30 cm apart and 25 cm between plants, using 40 kg. of seed per hectare. At the same time the rice is seeded interplant every fourth rice row with maize at the rate of one hill of maize per meter. This will give 10,000 corn plants per hectare which will help cover the ground while causing little or no reduction in rice yield.

9. When the rice grains reach the early dough stage of maturity, interplant with soybeans in single rows equidistant between the maize rows, spaced 12.5 cm apart in the row. Since the soybeans will be small at the time of the rice harvest they will receive minimum change in the process. Up to the time of the germination of the soybeans the weeds may be controlled with herbicides or hand

tools. After the soybeans germinate, only hand tools may be used.

10. If the following year's rotation includes maize as the principal crop, ridges should be built one meter apart before seeding.

C. System III: Maize/Peanuts: Hand Labor

11. Plant maize on ridged rows one meter apart, 25 cm apart in the row (System I, above). Control weeds as indicated in System I. When the maize is in flower, plant peanuts on both sides of the ridge. The peanut rows will be 50 cm apart and 25 cm between plants. Keep weeds under control by hand tools. If the ridges erode or broaden excessively from the force of heavy rains, build them up again with shovel or hoe to assure soft soil for the penetration of the peanut spikes from the bloom. The land may be used for maize and/or rice the following year.

D. System IV: Vegetables/Maize: Hand Labor

12. Plant maize on ridged rows as in System I above, except that the spacing between plants in the row will be 50 cm, giving a plant population of 20,000 per hectare. Plant the vegetable seed two weeks after the emergence of the maize plants. Vegetables seed may be intermingled or planted in blocks of pure stands. All vegetable

seed or plants are placed in the ridge between maize plants.

13. When maize is two weeks old plant:

Species	Spacing
Sweet potatoe	25 cm apart in each row of maize
	(2 ..plants between each two hills of maize)
Tomatoe	1 meter apart in each row of maize
Pepper	50 cm " " " "
Onion	12 cm " " " "
Field peas	12 cm " " " "
Beans	12 cm " " " "
Cucumber	2 meters " " " "
Egg plant	50 cm " " " "

14. This system considers vegetables the principal crop. The maize, which will not materially reduce vegetable yields, is included to provide ground cover to suppress weeds.

15. Some of the above species would probably respond better when interplanted with winter maize. Such crops as lettuce, cabbage, carrots and beets must be planted in the winter in order to respond well in the project area.

E. System V : Maize/Kudzu: Hand Labor

16. At the beginning of the third crop year after slashing and burning, maize is planted on ridged land (System I, above). Unridged land may also utilize this system where the farmer has a severe labor constraint or is just beginning to adopt multiple cropping technology. Maize will be planted at 25 cm intervals in one-meter rows which gives a plant population of 40,000 per hectare. While the maize seed is germinating, kudzu is interplanted between the maize on the same ridge or in the same row. Two or three seeds are planted 2 cm deep between every second and third plant, which will require approximately two kg of kudzu seed per hectare. Alternatively, root crowns from other, local stands may be interplanted at one meter intervals in the row of corn. Care must be taken not to allow the root crowns to dehydrate from the time they are dug until they are transplanted. The kudzu plant has up to 25% protein in the leaf on a dry matter basis. Cattle and swine thrive on it as their only forage. Grazing may be started when the kudzu has covered the ground. Overgrazing will kill it. Grazing must be stopped before all the leaves are removed.

17. The ground cover should be retained for at least two years as a weed suppresant and soil builder; however, it can be used for pasture as long as the farmer desires. Weeds or weedy growth that emerge above the kudzu cover should be cut back to ground level at least twice a year.

18. Removing stumps mechanically will be considerably easier and more economical after the land has been covered with kudzu for at least two years. The clearing operation and/or burning will destroy the kudzu sufficiently to permit returning the land to the production of annual crops. Experiments in the U.S. show increased maize yields following kudzu, compared to yields of maize following maize or other non-leguminous crops, due to the fixation of nitrogen and the deposit of organic matter by kudzu.

19. Other vigorous, vine-type legumes such as Dolichus lab lab or centrocema may be grown in the place of kudzu. Cultural practices are similar to that of kudzu. Legumes that are well adapted to the San Julian area and are palatable to livestock should be used.

F. Mixed Systems

20. The most important concept of multiple cropping is to keep the ground shaded or covered as much of the year as possible to supress weeds. The above described multiple cropping system may be varied for the wet, medium and dry micro-climatic zones in the San Julian project area. The crop mix may be changed to include different combinations of burrently grown crops or to accommodate new crops as they are introduced and are proven profitable.

21. Where residual moisture permits,an additional annual legume or field crop may be planted between the rows of the last crop occurring in the system. Such crops as pigeon peas (Cajanus cajan) or sesbania may be planted and left on the land until the farmer wishes to utilize it again for annual crops. Sesame, wheat, cowpeas, peanuts, burseem clover or lentils may be planted when annual crops are to grow in the following crop year.

22. Viney legumes such as kudzu or centrocema should be planted under all fruit trees as a ground cover. Care must be taken to keep the vines out of the trees. A one-half meter clean circle should be maintained around the base of each tree to reduce losses from fungus and bacterial diseases.